NAVAL AIR TRAINING COMMAND

NAS CORPUS CHRISTI, TEXAS **CNATRA P-431 (Rev. 09-21)**

FLIGHT TRAINING INSTRUCTION

NIGHT VISION GOGGLE PHASE

TH-57C

2021

DEPARTMENT OF DEFENSE
UNITED STATES OF AMERICA

DEPARTMENT OF THE NAVY
CHIEF OF NAVAL AIR TRAINING
250 LEXINGTON BLVD SUITE 179
CORPUS CHRISTI TX 78419-5041

CNATRA P-431
N714
14 Sep 21

CNATRA P-431 (REV 09-21)

Subj: FLIGHT TRAINING INSTRUCTION, NIGHT VISION GOGGLE PHASE, TH-57C

1. CNATRA P-431 (Rev 09-21) PAT, "Flight Training Instruction, Night Vision Goggle Phase, TH-57C," is issued for information, standardization of instruction, and guidance to all flight instructors and student military aviators within the Naval Air Training Command.

2. This publication is an explanatory aid to the Helicopter curriculum and shall be the authority for the execution of all flight procedures and maneuvers herein contained.

3. Recommendations for changes shall be submitted via the electronic Training Change Request (TCR) form located on the Chief of Naval Air Training (CNATRA) website.

4. CNATRA P-431 (New 03-21) PAT is hereby cancelled and superseded.

K. H. DELANO
By direction

Releasability and distribution:
This instruction is cleared for public release and is available electronically only via Chief of Naval Air Training website, https://www.cnatra.navy.mil/pubs-pat-pubs.asp.

FLIGHT TRAINING INSTRUCTION

FOR

NIGHT VISION GOGGLE PHASE

TH-57

Q-2C-3156

LIST OF EFFECTIVE PAGES

Dates of issue for original and changed pages are:
Original...0...3 Mar 21 (this will be the date issued)
Revision...1...14 Sep 21

TOTAL NUMBER OF PAGES IN THIS PUBLICATION IS 112 CONSISTING OF THE FOLLOWING:

Page No.	**Change No.**	**Page No.**	**Change No.**
COVER	0	6-1 – 6-5	0
PROMU LETTER	0	6-6 (blank)	0
iii – xi	0	7-1 – 7-6	0
xii (blank)	0	8-1 – 8-18	0
1-1 – 1-5	0	A-1 – A-4	0
1-6 (blank)	0	B-1	0
2-1 – 2-10	0	B-2 (blank)	0
3-1 – 3-20	0		
4-1 – 4-11	0		
4-12 (blank)	0		
5-1 – 5-15	0		
5-16 (blank)	0		

INTERIM CHANGE SUMMARY

The following Changes have been previously incorporated in this manual:

CHANGE NUMBER	REMARKS/PURPOSE

The following interim Changes have been incorporated in this Change/Revision:

INTERIM CHANGE NUMBER	REMARKS/PURPOSE	ENTERED BY	DATE

SCOPE

This publication contains maneuvers introduced in the Night Vision Goggles (NVG) stage of the Advanced Helicopter Multi-Service Pilot Training System Master Curriculum Guide (CNATRAINST 1542.156 series). It is your responsibility to have a thorough knowledge of its contents.

CHANGE RECOMMENDATIONS

Change recommendations to this publication may be submitted by anyone to Commander Training Air Wing FIVE and CNATRA N7, a process which improves training curricula and its associated training publications. This includes all personnel involved at every level of flight training. A Training Change Request (TCR) form should be completed and submitted for routing to the standardization office of your respective squadron. Remember, no TCR is too small.

TABLE OF CONTENTS

LIST OF EFFECTIVE PAGES .... **iv**
INTERIM CHANGE SUMMARY .... **v**
TABLE OF CONTENTS .... **vii**
TABLE OF FIGURES .... **ix**
INTRODUCTION .... **xi**

CHAPTER ONE – THE NIGHT ENVIRONMENT **1-1**
100. SCOPE 1-1
101. THE NIGHT ENVIRONMENT 1-1
102. REFLECTED VS. RADIANT ENERGY 1-1
103. NVG PERFORMANCE FACTORS 1-2
104. NVG TERRAIN CONSIDERATIONS 1-4
105. ATMOSPHERIC CONDITIONS 1-5

CHAPTER TWO – AN/AVS-9 NIGHT VISION GOGGLES **2-1**
200. SCOPE 2-1
201. NVG DESCRIPTION 2-1
202. AN/AVS-9 BINOCULAR ASSEMBLY 2-1
203. AN/AVS-9 ACCESSORIES 2-6
204. NVG POWER SOURCES 2-7
205. NVG HELMET MOUNTING 2-8
206. TH-57 AIRCRAFT LIGHTING CONSIDERATIONS 2-9

CHAPTER THREE – NIGHT VISION GOGGLE PREFLIGHT AND POSTFLIGHT PROCEDURES **3-1**
300. SCOPE 3-1
301. NVG PREFLIGHT 3-1
302. ALIGNMENT PROCEDURES 3-7
303. ANV-20/20 NVG INFINITY FOCUS DEVICE – THE HOFFMAN BOX 3-11
304. FOCUS PROCEDURES 3-13
305. NVG IMAGE ASSESSMENT PROCEDURES 3-16

CHAPTER FOUR – NIGHT VISION GOGGLE SCENE INTERPRETATION **4-1**
400. SCOPE 4-1
401. NVG MAP SELECTION 4-1
402. NVG MISSION PLANNING 4-1
403. MISSION EXECUTION 4-3
404. SOLAR/LUNAR ALMANAC PREDICTION (SLAP) PROGRAM 4-4
405. NVG SCENE INTERPRETATION 4-8
406. COMMON NVG SCENE DESCRIPTIONS 4-9
407. LLL CONSIDERATIONS 4-11

CHAPTER FIVE – NVG AEROMEDICAL FACTORS **5-1**
500. SCOPE 5-1
501. VISUAL ACUITY 5-1

502. VISION TYPES 5-2
503. DARK ADAPTATION 5-2
504. NIGHT BLIND SPOT 5-3
505. PERIPHERAL VISION 5-5
506. OBSTRUCTION DETECTION 5-6
507. HUMAN FACTORS 5-7
508. FATIGUE 5-8
509. TYPES OF FATIGUE 5-9
510. CIRCADIAN RHYTHM 5-10
511. VISUAL ILLUSIONS 5-11

CHAPTER SIX – NVG BRIEFING AND SAFETY CONSIDERATIONS 6-1
600. SCOPE 6-1
601. MISSION BRIEFING PROCEDURES 6-1
602. AIRCRAFT EMERGENCIES 6-2
603. INADVERTENT INSTRUMENT METEOROLOGICAL CONDITIONS (IIMC). 6-3
604. NVG FAILURES 6-3

CHAPTER SEVEN – NVG INTEGRATED SCAN 7-1
700. SCOPE 7-1
701. ATTITUDE FLIGHT 7-1
702. BREAKDOWN IN SCAN 7-2
703. SCAN AT ALTITUDE 7-3
704. HOVER SCAN 7-3
705. INCORPORATION OF UNAIDED HOVER SCAN 7-4
706. HOVER SCAN FIXATION 7-4
707. CONTACT PATTERN 7-5

CHAPTER EIGHT – NVG MANEUVERS 8-1
800. SCOPE 8-1
801. VERTICAL TAKEOFF 8-1
802. HOVERING 8-2
803. TURN ON SPOT/CLEARING TURN 8-3
804. NVG TRANSITION TO FORWARD FLIGHT 8-5
805. NVG NO HOVER TAKEOFF 8-7
806. NVG APPROACHES 8-9
807. NVG NORMAL APPROACH 8-9
808. NVG STEEP APPROACH 8-11
809. WAVE-OFF – POWER ON 8-14
810. VERTICAL LANDING 8-15
811. NO HOVER LANDING 8-16
812. QUICK STOP 8-17

APPENDIX A – GLOSSARY A-1

APPENDIX B – FORMATION AND NVG COVER SHEET B-1

TABLE OF FIGURES

Figure 1-1 EM Spectrum 1-1
Figure 1-2 Illuminance and Luminance 1-2
Figure 1-3 Twilight Levels 1-4

Figure 2-1 Binocular Assembly 2-2
Figure 2-2 Image Intensifier (I^2)Tube Components 2-2
Figure 2-3 MCP 2-3
Figure 2-4 Diopter Adjustment 2-4
Figure 2-5 NVG Mount 2-6
Figure 2-6 NVG Adjustment 2-6
Figure 2-7 NVG Control Functions 2-7
Figure 2-8 NVG Battery Packs 2-8

Figure 3-1 NVG Inspection and Adjustment Procedures (Steps 1 through 3) 3-2
Figure 3-2 NVG Inspection and Adjustment Procedures (Steps 4 and 5) 3-3
Figure 3-3 NVG Inspection and Adjustment Procedures (Step 6) 3-4
Figure 3-4 NVG Inspection and Adjustment Procedures (Step 7) 3-5
Figure 3-5 NVG Inspection and Adjustment Procedures (Step 8) 3-5
Figure 3-6 NVG Inspection and Adjustment Procedures (Step 9) 3-6
Figure 3-7 NVG Binocular Assembly Mounting 3-7
Figure 3-8 NVG Alignment and Sight Picture 3-8
Figure 3-9 AN/AVS-9 Alignment Procedures (Steps 3 through 5) 3-9
Figure 3-10 NVG Alignment Procedures (Step 6) 3-10
Figure 3-11 ANV-20/20 NVG Infinity Focus Device Front Control Panel 3-11
Figure 3-12 ANV-20/20 NVG Infinity Focus Test Pattern 3-12
Figure 3-13 Optimal Eyepiece or Diopter Adjustment 3-14
Figure 3-14 NVG Focus Procedures 3-15
Figure 3-15 Image Defects 3-17

Figure 4-1 JMPS LDI/LEAA Step 1 4-5
Figure 4-2 JMPS LDI/LEAA Step 2 4-5
Figure 4-3 JMPS LDI/LEAA Step 3 4-6
Figure 4-4 JMPS LDI/LEAA Step 4 4-6
Figure 4-5 JMPS LDI/LEAA Step 5 4-7
Figure 4-6 JMPS LDI/LEAA Step 6 4-7

Figure 5-1 Human Visual System 5-1
Figure 5-2 Types of Vision 5-2
Figure 5-3 Rod and Cone Sensitivity 5-3
Figure 5-4 Central and Peripheral Vision 5-4
Figure 5-5 Night Blind Spot 5-4
Figure 5-6 Off-center Vision Technique 5-5
Figure 5-7 Angular Size Difference 5-6
Figure 5-8 Typical Circadian Cycle 5-11

Figure 5-9 False Horizon Illusion 5-12
Figure 5-10 Confusion with Ground Lights and Stars 5-13
Figure 5-11 Size Constancy 5-14

Figure 7-1 NVG Field of View (FOV) vs. NVG Field of Regard (FOR) 7-2
Figure 7-2 NVG Hover Scan Locations 7-4
Figure 7-3 NVG Final Approach Scan Locations 7-6

Figure 8-1 NVG Takeoff Envelope (Blue Hashed Area) vs. Normal Takeoff Profile (Black) 8-5

Figure B-1 Cover Page Sample B-1

INTRODUCTION

This Flight Training Instruction provides amplifying information regarding the application of Night Vision Goggles (NVGs) specific to TH-57 rotary wing operations.

The ***MAWTS-1 Night Vision Device (NVD) Manual*** is the primary source of information regarding the proper use and application of NVDs in Navy/Marine Corps aviation. This publication will include appropriate references to the ***MAWTS-1 NVD Manual*** for topics you, the student, are responsible for. The information within this publication is supplementary and focuses on maneuvers and specific application of Night Vision Goggles (NVGs) to the TH-57 helicopter.

The terms Night Vision Goggle (NVG) and Night Vision Devices (NVD) are not interchangeable. The term NVG refers specifically to devices worn by aircrew that use image intensification technology to form an image of the night scene. The term NVD refers to all devices which take advantage of various bands of the Electromagnetic Spectrum to generate useful imagery to aircrew in the night environment. These devices include NVGs and Forward Looking Infrared (FLIR) systems that are found on fleet platforms. FLIR use will not be a part of the training curriculum in the TH-57, and information regarding FLIR within the MAWTS-1 Manual is beyond the scope of this phase of training.

The student will have to apply the fundamentals learned from the previous stages of instruction to successfully complete this culminating stage of Advanced Rotary Wing Training. The purpose of this stage is to prepare the student to integrate NVG use into basic helicopter flight and navigation.

THIS PAGE INTENTIONALLY LEFT BLANK

CHAPTER ONE
THE NIGHT ENVIRONMENT

100. SCOPE

Welcome to the Night Vision Goggles (NVG) environment. NVG systems operate in the optical radiation portion of the electromagnetic spectrum. Other portions of the electromagnetic spectrum react differently to the environment than visible light does. The lack of understanding of the night environment and its impact on NVG performance can potentially result in an unsuccessful mission or an NVG related mishap. In the past, several NVG related mishaps have demonstrated a lack of aircrew knowledge regarding the fundamental capabilities and limitations of NVGs. This chapter will address how the night environment influences NVG performance.

101. THE NIGHT ENVIRONMENT

In order to understand the impact of the night environment on NVG performance, aircrew must understand the energy available in the night sky and its relationship to the eye and electro-optical systems. Just as a radio must be tuned to receive specific frequencies, NVGs and the human eye possess selective sensitivity to different wavelength or frequency ranges on the Electro Magnetic (EM) spectrum. These wavelength or frequency bands are inherently similar in nature and can best be related or described by their position on the EM spectrum. The optical band covered by visible light is a relatively small portion of the entire EM spectrum.

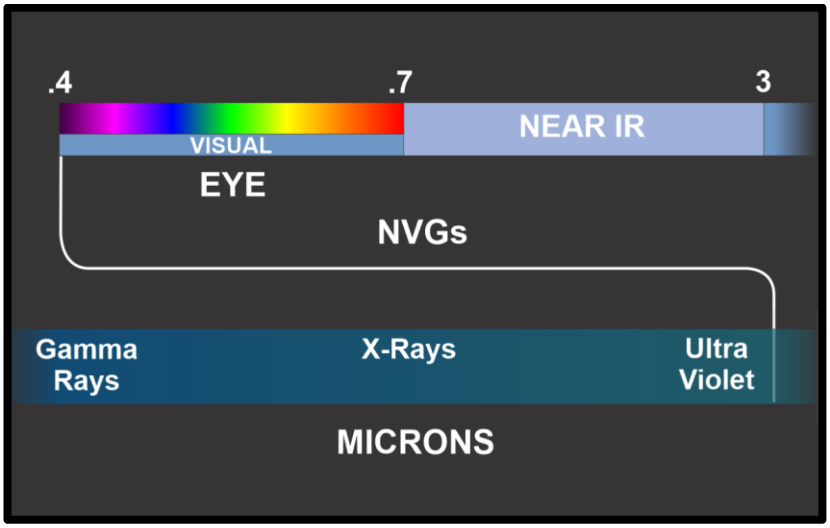


Figure 1-1 EM Spectrum

102. REFLECTED VS. RADIANT ENERGY

Energy is constantly being radiated or reflected by all of the objects in view of aircrew. Below three microns, the background is dominated by reflected and scattered solar or lunar radiation. NVGs operate in this portion of the spectrum, both in the visible and near infrared (IR). Since reflection dominates the portion of the spectrum that NVGs occupy, they are dependent entirely on some sort of external illumination to view the scene. This illumination can come from the moon, stars, cultural (city) lighting, and, in some cases, even the sun. For example, when a scene is illuminated by an external source such as the moon, the scene is observed primarily by reflected energy. Reflected light (***luminance***) is normally expressed in terms of foot-lamberts (ft-L), while the amount of light generated from a source (***illuminance***) is expressed in terms of the unit lux or lumens per square meter (lm/m2).

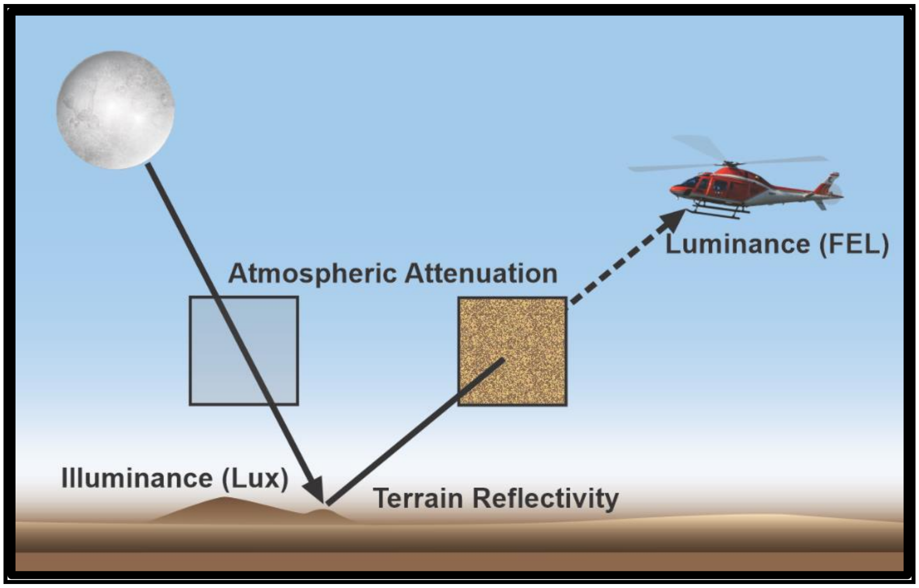


Figure 1-2 Illuminance and Luminance

103. NVG PERFORMANCE FACTORS

The three primary factors that influence NVG performance are illumination, terrain contrast, and atmospheric conditions. Understanding how these factors impact NVG performance will improve mission planning and execution.

– Illumination

Illumination is a critical factor for NVG operations. Illumination for night operations can come from both natural and artificial sources and is typically expressed using lux or lumen/meter^2 units.

a. Lunar Illumination. The moon is usually the primary source of natural illumination for NVG operations. The moon reflects about seven percent of the sunlight that strikes it. The amount of light the moon provides is highly variable and influenced by the following four factors.

   i. Moon phase (lunar cycle). The primary lunar illumination factor is lunar cycle or phase (e.g., new, full, quarter, etc.). Each moon phase provides different levels of illumination. A lunar month is approximately 29.5 days. Moon phases are influenced by the time of year and global position (latitude and longitude).

ii. Moon angle. Moon angle, elevation, or altitude in relation to the horizon is the second most significant factor affecting lunar illumination. The moon is at its brightest when it is directly overhead and provides less illumination as it rises or sets. Many people will look at a low angle full moon and assume high illumination, however, a quarter moon high overhead can actually be brighter. Moon altitude is also important because of the phenomenon known as terrain shadowing which will be discussed later.

iii. Lunar albedo. A difference in the albedo (reflectance) of the illuminated portions of the moon surface during the lunar cycle is the third factor. For example, the moon is about 20% brighter during the first quarter (waxing) than the third quarter (waning) due to differences in the lunar surface.

iv. Earth-Moon distance. The final and least significant factor is the variation in the earth-moon distance due to the elliptical nature of the lunar orbit around the earth. The changes in illumination resulting from a 5% difference in distance are deemed insignificant for NVG purposes.

b. Night Sky Illumination. Moonless nights also have significant usable light for NVG operations. This is due to the large near-IR composition of night sky illumination. This night sky near-IR energy matches the peak sensitivity of the AN/AVS-9 NVG. On a moonless night, about 40% of the light is provided by emissions from atoms and molecules in the upper atmosphere known as air glow. Starlight is the other significant light source and provides about 0.00022 lux (about one tenth the level of a quarter moon).

c. Solar Influence. Depending upon the azimuth and relationship to the flight path, the sun can provide adequate light (sky glow) for NVG operations until after nautical twilight (7-12 degrees below the horizon). Civil twilight (0-6 degrees below) is too bright, and astronomical twilight (13-18 degrees below) is too dark for NVG operations (considering only the contribution of the sun). Although the sun may provide helpful illumination if aircrew are flying away from it, a sun that is well below the horizon can continue to be a significant nuisance if flying toward it, especially in mountainous terrain. This is because of potential activation of the NVG's automatic gain circuitry (Bright Source Protection (BSP). For NVG aided operations, aircrew should plan for NVGs to be most effective following the end of evening nautical twilight or when the sun has set more than 12 degrees below the horizon (roughly 45 to 60 minutes after sunset, depending on latitude).

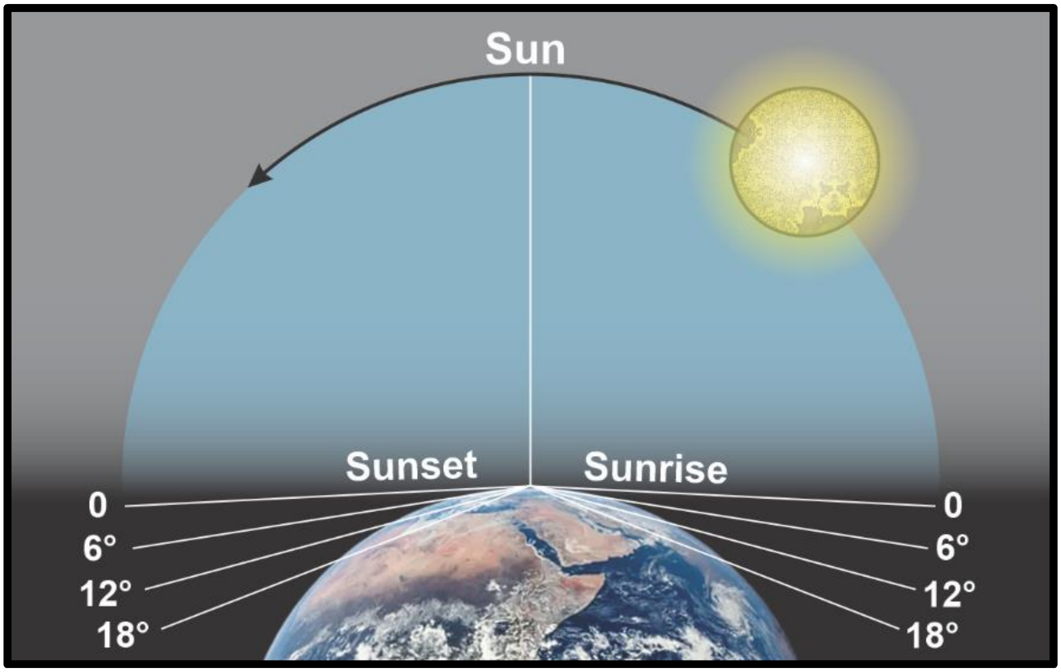


Figure 1-3 Twilight Levels

104. NVG TERRAIN CONSIDERATIONS

Terrain considerations must be understood when discussing NVG performance. There are three primary terrain factors that need to be examined for proper NVG mission planning:

1. Terrain albedo (reflectivity) will greatly influence the overall scene luminance available for NVG operations. Surfaces such as snow will reflect more light than surfaces like asphalt or dark rock and therefore will appear lighter in the NVG image. The ability to see terrain features with NVGs is solely a function of the amount of light reflected by the terrain.

2. Terrain contrast is a measure of the difference between the albedos of two or more surfaces. The greater the difference in contrast, the easier it is to see terrain or objects.

3. Terrain shadows form at night just as they do during the day. Anything blocking moonlight will create a shadow. This can include terrain, cultural objects, and even aircraft. One big difference between day and night shadows is the amount of energy present inside the shadow. During the day, the human eye can see into shadows due to the large amount of energy still inside the shadow while at night there is much less energy available. However, shadows may also provide benefits such as helping to discern terrain features while flying over low contrast terrain like sand dunes.

105. ATMOSPHERIC CONDITIONS

The following factors have a significant impact on NVG performance:

1. Humidity

Atmospheric water vapor (humidity) is the most influential absorbing gas, and certainly the most variable. Local humidity conditions can easily double the water vapor content in a matter of hours such as seen with a changing weather front. Humidity effects on NVG performance vary with particle size and density. Because of the properties of near IR light, the NVGs can “see through” light fog and thin clouds where unaided vision cannot; however, the quality of the NVG image, just like in unaided vision, becomes worse as humidity levels increase.

2. Scattering

Scattering is a phenomenon that occurs when light strikes a particle and changes its path. This scattering energy causes attenuation of the signal. The effects of scattering can be significant in an environment full of dust or smoke causing an appreciable loss in NVG performance.

THIS PAGE INTENTIONALLY LEFT BLANK

CHAPTER TWO
AN/AVS-9 NIGHT VISION GOGGLES

200. SCOPE

This chapter will introduce the AN/AVS-9 Night Vision Goggle (NVG) system, describe its associated components, and outline setup procedures.

201. NVG DESCRIPTION

NVGs are passive sensors that utilize image intensifier tube technology. An image intensifier tube is an electronic device amplifying available atmospheric illumination or light (e.g., moon, stars, sun, cultural lighting, etc.). NVGs rely upon the illumination reflected off the terrain or a target to form an image presented to the aircrew as a green monochromatic representation of the world. NVGs operate using the same principles as the human eye (reflected energy), with the following two exceptions:

- NVGs are exponentially more sensitive to illumination than the human eye.

- NVGs are sensitive to a different portion of the electromagnetic spectrum than the human eye.

202. AN/AVS-9 BINOCULAR ASSEMBLY

This systems-oriented section will provide a brief overview of the components of the AN/AVS-9 NVG.

1. **Objective Lens**

The first optical component of the NVG is the objective lens. The lens is actually a combination of optical elements that function to focus the incoming rays of light onto the Image Intensifier (I^2) tube. The AN/AVS-9 objective lens possesses variable focus with a focal range spanning from 41 cm to beyond optical infinity (150 feet). These shorter focal distances allow for NVG use in weapons systems trainers or simulators. Although the objective lens possesses a large range of focus, the depth of field dramatically decreases at short distances. Therefore, as aircrew optimize the NVGs for flight (optical infinity) and glance inside the aircraft looking through the NVG or view objects a short distance away, the objects will appear out of focus. NVG “minus blue” objective lens filtering facilitates aircraft cockpit and display compatibility by restricting wavelengths of energy entering the intensification process. This allows the use of cockpit lighting that will not adversely affect NVG gain and ultimately NVG image quality. This objective lens characteristic can be readily observed by looking at the AN/AVS-9 objective lenses. The objective lenses appear blue. This results from the lens filtering that “rejects” energy with a wavelength less than 665 nm. This “rejected” energy appears blue to the unaided eye.

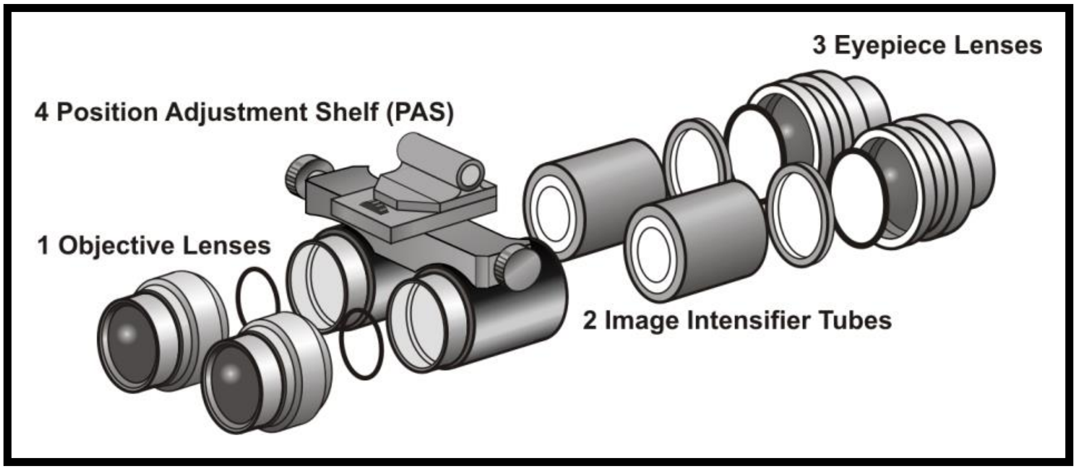


Figure 2-1 Binocular Assembly

2. **Image Intensifier (I^2) Tube Components**

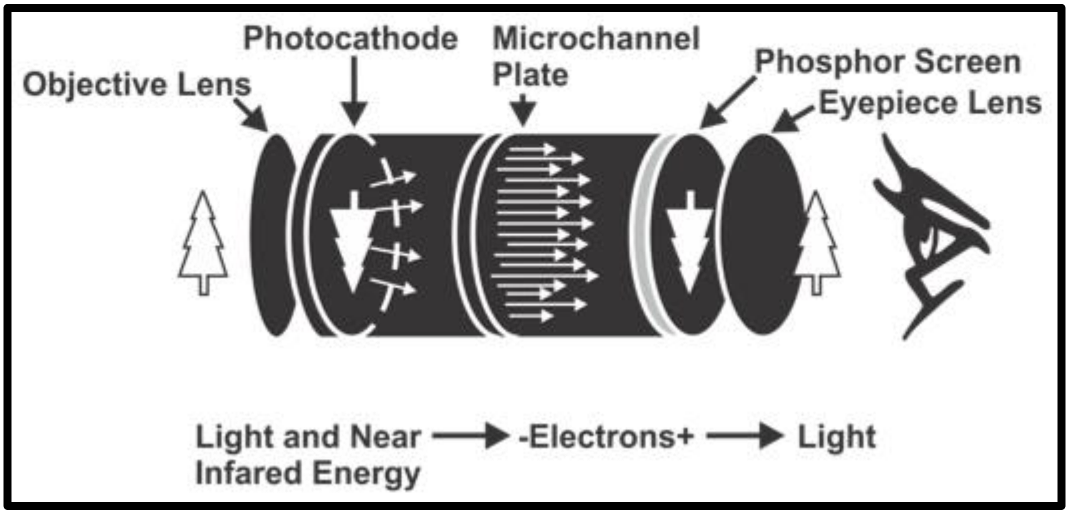


Figure 2-2 Image Intensifier (I^2) Tube Components

3. **GEN 3 I^2 tubes possess three primary internal components:**

   a. **Photocathode.** The photocathode is responsible for converting the incoming visible and near IR energy into electrical energy in the form of electrons. Since the sensitivity of the photocathode extends into the near IR, it is able to detect energy in that region which is invisible to the human eye. The Gallium Arsenide (GaAs) photocathode in the third generation tubes has a peak sensitivity from approximately 600-900nm (0.6-0.9 micron range). This is significant since the night sky spectral irradiance is 5 to 7 times greater in the region of 800-900nm than in the visible region near 500nm. As a result the third generation tube is far more sensitive in the region where near infrared light from the night sky is plentiful.

b. **Microchannel Plate (MCP).** Electrons exiting the photocathode are channeled next through the MCP (Figure 2-**3**). The MCP is a very thin (1 mm) wafer comprised of millions of tiny glass tubes or channels, and is located between the photocathode and the phosphor screen. The inside passages of the MCP tubes are coated with a material that causes secondary electron emissions when a passing electron strikes them. The tiny glass tubes are tilted, at an approximate five degree bias angle, to ensure a first electron impact near the channel entrance. As each electron strikes a wall, more electrons are emitted from the wall, each of which will in turn strike the wall again, creating a cascading electron multiplier effect. Because of this process, for each electron that enters the MCP, 1000 or more will exit. The MCP is coated with an aluminum oxide film, this film is transparent to electrons but not ions. End of service life for a photocathode is primarily caused by positive ion contamination. The only repercussion is a voltage increase between the photocathode and the MCP. This in turn requires increased spacing between the two components to prevent arcing. This spacing causes an increased halo when viewing bright light sources.

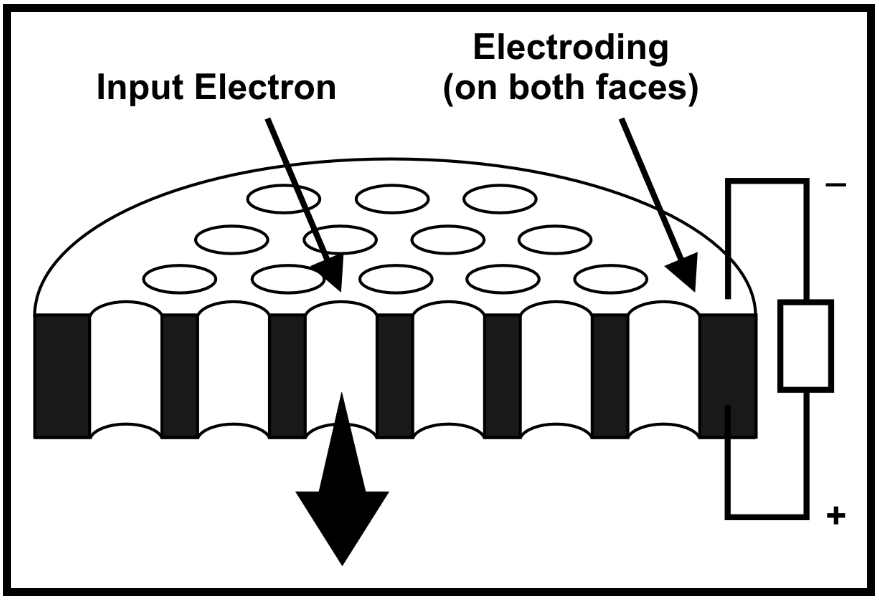


Figure 2-3 MCP

c. **Phosphor Screen**. Electrons exiting the MCP are in turn accelerated forward, maintaining their relative spatial position, until they strike and excite the phosphor screen (Figure 2-2). The phosphor screen is comprised of a very thin layer of phosphor deposited on the inside of the rear window (fiber optic). The basic function of the phosphor screen is to convert the electron beam energy to light. The screen is charged with a positive potential of several thousand volts with respect to the MCP to accelerate and attract the negatively charged electrons exiting the MCP. Phosphors emit light when electrons strike them and the output light wavelength is a function of the type of phosphor used. The AN/AVS-9 uses P43 phosphor with a spectral output that closely matches the peak sensitivity of the human eye.

WARNING

> Take caution when handling NVGs. The phosphor screen material is very toxic. If there is serious damage to the NVG housing frame, it may allow toxic phosphor screen material to escape. Do not inhale or touch this material.

4. Fiber Optic Inverter

Image inversion is accomplished by attaching the phosphor screen to a **fiber optic inverter**. This inverter is actually a bundle of millions of microscopic light-transmitting fibers that are heated and given a 180° twist providing the needed inversion to produce an upright image without requiring a second lens assembly. The fiber optic inverter also collimates the image, making the image at the eyepiece lens appear to be at the appropriate distance from the viewer.

5. AN/AVS-9 Eyepiece / Diopter Assembly

Eyepiece Lens. The eyepiece lens is the final optical component of the AN/AVS-9 NVG. As with the objective lens, the eyepiece lens is a series of optical components. The function of the eyepiece lens is to focus the light from the phosphor screen and fiber optic inverter onto the eye. The diopter adjustment for this lens allows wearers to move the focus point to the appropriate location at the back of the retina. The diopter lens will allow for mild vision corrections, however all students who require vision correction for flight shall wear corrective lenses during aided flight.

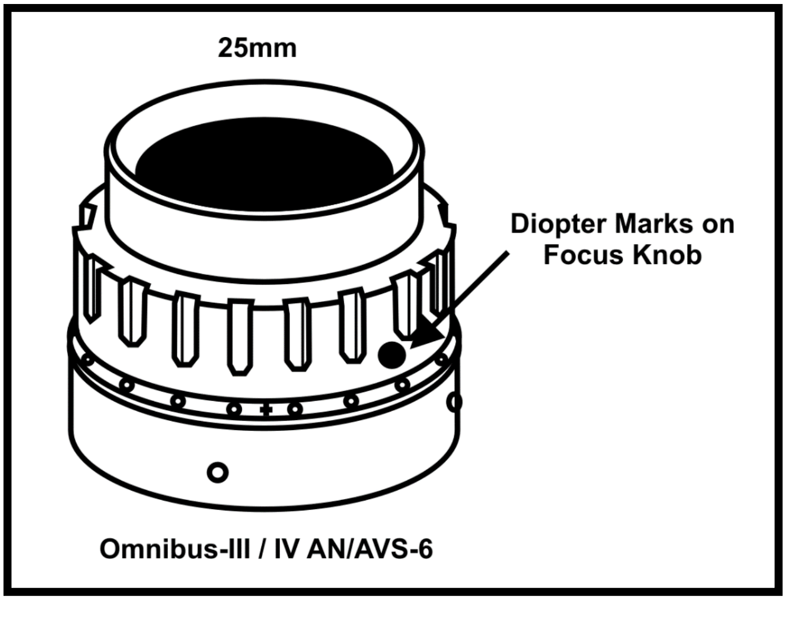


Figure 2-4 Diopter Adjustment

6. Image Intensifier Tube Automatic Gain Control System

The primary function of NVGs is to amplify the photons of light entering into the system. The amount that the input photons are amplified is called gain. Essentially, gain will govern the NVG image brightness for low light level (LLL) inputs.

Constant exposure of the image intensifier tube to bright light sources may result in damage to the photocathode or the MCP. ***Therefore, NVGs should never be exposed to bright light.*** To prevent damage to the I^2 tubes, the power supply has been designed with two automatic protection features designed to control the gain of the I^2 tube, extend NVG service life, and have a direct effect on the performance and resolution of the NVGs.

7. Automatic Brightness Control (ABC) Circuit

The ABC circuitry automatically adjusts MCP voltage to maintain NVG image brightness at a preset output for a wide range of illumination levels by controlling the number of electrons that exit the MCP. This function causes the NVG to “gain up” or “gain down” according to the light level. Therefore, the benefit derived from high gain intensifier tubes is realized only at low illumination levels since above a certain illumination level, the ABC holds image brightness constant. Tube gain increases from full moon down to star light illumination. As light levels pass below star light, further decreases in illumination do not result in an increase in I^2 tube gain. Therefore, the NVG image starts to decrease in brightness and contrast while NVG image scintillation becomes visible. The ABC circuit also provides a protective function to aircrew by limiting the effect of sudden bright flashes (e.g., forward firing munitions, etc.).

8. Bright Source Protection (BSP)

Image intensifier tube exposure to bright light sources, left unchecked, could result in damage to the photocathode, the MCP, and the eye. The BSP circuit limits the number of electrons leaving the photocathode by reducing the voltage between the photocathode and the input side of the MCP. The BSP circuit actually starts to take effect at fairly low light levels and has an increasing effect until the voltage drops to the point needed to ensure that electrons can penetrate the MCP ion barrier film. Aircrew will notice activation of the BSP when an incompatible light source enters the NVG field of view and the I^2 tube significantly “de-gains” leading to reduced NVG image contrast and detail.

203. AN/AVS-9 ACCESSORIES

– Quick Don Lock Mount

The mount possesses the vertical adjustment control, the lock release button, and the low battery indicator. The low battery LED indicator located on the bottom of the mount will illuminate when battery voltage drops below 2.2 volts, signaling the user that remaining battery life is low. In addition the Quick Don Mount allows the binocular assembly to break away from the helmet during a crash at loads of 10-15G's.

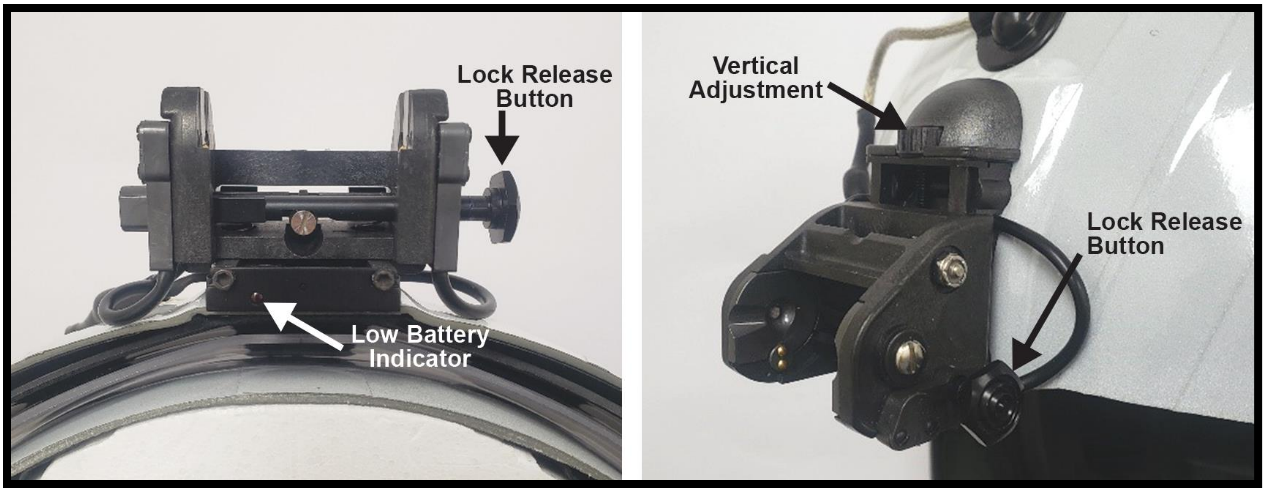


Figure 2-5 NVG Mount

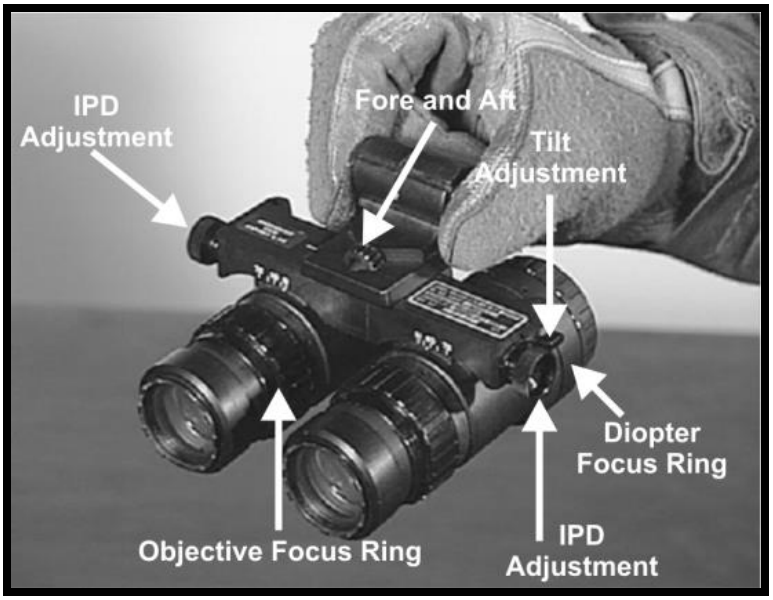


Figure 2-6 NVG Adjustment

Controls and Indicators	Function
Power Switch (ON/OFF/ON)	**ON:** binocular on – power drawn from battery compartment to which switch points **OFF:** binocular off
Objective Focus Rings (41 cm to Optical Infinity)	Focuses the objective lenses. Adjust sharpest view of scene. Travel for the objective lens focus ring is 1/3 turn.
Eyepiece Diopter Adjustment Rings (+2 to -6 Diopters)	Adjusts the intensified image from the I^2 tube back to the retina and can compensate for refractive errors but not for astigmatism. ***Movement of the fore-and aft adjustment requires readjustment of the eyepiece lens focus ring.***
Eye-span (IPD) Adjustment Knob (51 to 72 mm)	Adjusts for operator eye span or interpupillary distance (IPD). **Dual IPD PAS**: Independent control of each monocular.
Fore-and-Aft Adjustment Knob (Eye Relief) (25 mm)	Adjustment for optimum field of view. Turn the knob to obtain a full view of the intensified image. Adjust fore-and-aft to maximize the field of view, yet maintain your peripheral view, and "look under" capability.
Vertical Adjustment Knob (16 mm Total Travel)	Moves the binocular up or down. Center the eyepieces in front of the eyes.
Tilt Lever (8 to 10° Total Travel)	Allows the binocular to be tilted up or down. Moves the lever to obtain the optimum line-of-sight viewing. Should be parallel to the PAS if possible.
Lock-Release Button	Press the lock-release button to rotate the binocular from the stowed position to down and ready for flight position.
Low-Battery Indicator (Steady or Flashes)	When illuminated, it indicates a low battery condition with approximately 2.2 volts of power remaining.

Figure 2-7 NVG Control Functions

204. NVG POWER SOURCES

There are currently two types of power sources used with the AN/AVS-9R: the Low Profile Battery Pack (LPBP) and the Clip-On Power Supply. The LPBP contains a primary and redundant power source and a three-position switch. It will only accept AA alkaline batteries, and comes with a hard mounting bracket. The Clip-On Power Supply is designed for hand held use of the NVGs.

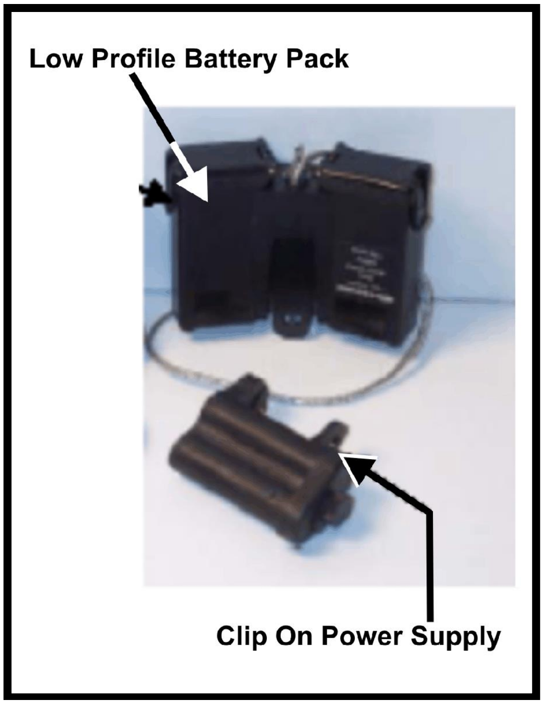


Figure 2-8 NVG Battery Packs

The AN/AVS-9 is powered by two 1.5-volt AA alkaline batteries. The service life of each battery will be affected by environmental temperature.

Alkaline AA battery performance demonstrated no drop-off in image brightness and quality for several hours (five - ten hours) following activation of the low battery indicator (2.2 volts). It is recommended aircrew fly the AN/AVS-9 with one set of new batteries installed on the back up (left) side of the battery pack with the previously used, but non expired set of batteries placed on the primary (right) side of the battery pack.

205. NVG HELMET MOUNTING

1. Helmet Fitting Procedures

A proper fit is critical for comfort, reduced neck fatigue, and keeping the NVG image in the correct position during maneuvering. If helmet fit is not optimal or loose after mounting NVGs see the Paraloft for adjustments to liners, nape strap, and chin strap. Counterweights are also available that attach directly to the LPBP and balance the forward weight of the NVGs.

2. Helmet Mount

The goggles are attached to the helmet on the helmet plate (bracket). The bracket is hand tooled during manufacture to ensure a proper connection with the NVGs. The NVG release lever on the mount assembly disengages a spring-loaded locking bar thereby enabling the goggles to be removed from the helmet with one hand.

WARNING

> Removal of the lanyard from the NVGs or twisting the lanyard around the upper part of the helmet is not authorized. The only authorized modification to the lanyard is the addition of Velcro to the cord and helmet by gear issue per the NAVAIR instruction.

206. TH-57 AIRCRAFT LIGHTING CONSIDERATIONS

The AN/AVS-9 has a Class-B objective lens filter tuned for spectral sensitivity from the red region of the visible spectrum and into the near IR spectrum from 665 nm to 900 nm. To avoid glare and reduction in outside visibility, interior aircraft lighting must be NVG compatible. The term “NVG compatible” refers to light sources whose spectral output falls below the spectral sensitivity range of the NVGs, and therefore minimizes adverse impacts on NVG performance. Rotary and tiltrotor aircraft cockpits can use interior light sources that fall below the 665nm threshold, in the blue-green area of the visible spectrum. The NVG does not ***“see”*** the output from blue-green lights; furthermore, light output in this range closely matches both peak sensitivity of the human eye and the color output of the NVG (545 nm). This allows the eye to effectively view blue-green lights at very low intensities.

1. TH-57 Interior Lighting

The TH-57 cockpit has a flat black instrument panel, which absorbs light and prevents unwanted reflections of incompatible light. In addition, the instrument panel backlighting is filtered in the blue-green spectrum, which virtually eliminates negative interactions with the NVG and works well with the NVG-adapted mesopic vision of the eye. Due to the increased gain of the NVGs, even the smallest escape of unfiltered light in the cockpit will have a negative effect on the goggles either directly or through windscreen glare. In the event of a failure of one of the blue-green light filters on the instrument panel, the crew will observe noticeable degradation of NVG performance.

Unlike in unaided night flight, the instrument panel lights should not necessarily be set to the dimmest level possible while still readable. Since the eyes are in an intermediate state of night adaptation (mesopic vision), instead of fully adapted scotopic (night) vision, the crew should set instrument panel lights to match the intensity of the NVG image. This will be the best way to accommodate the NVG-aided eye.

2. Position Lights

The port (red) position light will cast a distinct glow on the surrounding scene when observed from the cockpit. This will result in terrain on the port side of the aircraft being noticeably more illuminated, especially when near to the ground. Position lights should be set at the highest intensity level consistent with favorable NVG performance. As such, consideration should be given to using the “Dim” setting on the position lights when conducting LZ operations. The Bright/Dim setting may be adjusted by the aircraft commander if the lighting configuration interferes with safe flight operations. In general, when transiting at altitude away from the OLF, the Position Lights should be set to the “Bright” setting, and when conducting LZ operations at the OLF, they should be set to “Dim.”

3. Anti-Collision Lights

The Anti-Collision Lights can have adverse effects when close to the ground or in conditions of high humidity. Close to the ground, the Anti-Collision light will reflect off the terrain and can contribute to spatial disorientation. The same effect may be observed at altitude when in IMC or when near cloud banks. As such, the aircraft commander may elect to secure the Anti-Collision Lights when approaching the LZ, or at any other time they significantly degrade SA. Decisions regarding securing the Anti-Collision Lights must be balanced with FAA requirements and with other traffic considerations

4. Searchlight/Landing Light

In the TH-57, the searchlight/landing light will be used primarily while conducting low work in the line environment, or when trying to further illuminate an LZ in LLL conditions. The area illuminated by the beam of these lights will be much brighter and the area outside of the beam will appear darker on the NVGs.

a. Cultural Lights/Runway Environment

When flying in well-lit areas (e.g., runway/airfield environment, etc.) with increased cultural lighting, the searchlight can be used to “fight light with light,” by helping to reduce the blooming effects of bright incompatible light sources in the environment. By illuminating an area where bright light sources are present, the pilot can present the NVG with an image of more uniform level of brightness, causing the NVG to de-gain to match the scene and provide additional terrain detail.

b. High Humidity Levels

The NVGs can see through light fog and thin clouds, and these weather conditions may be undetectable by the crew; however, when there are light sources present in these conditions, the crew will observe larger halos around these sources when high humidity levels are present. The same concept applies to the use of the searchlight and landing light. When these lights are turned on at altitude when the relative humidity is high, the beam will be subject to reflection and absorption off the suspended water vapor molecules. These effects will result in de-gain of NVG, decreased scene detail outside the beam, and an obscured area of light in the beam. Depending on altitude and humidity level, the crew may have difficulty discerning the terrain below.

c. Dust, Sand, Other Solid Particulates

Another consideration is the effect that the searchlight/landing lights have in an LZ where the light is being scattered by airborne particles. By introducing the searchlight, more light is scattered off airborne particles and the visual environment is further degraded and obscured. Use of the searchlight in these environments can lead to spatial disorientation and possible CFIT.

CHAPTER THREE
NIGHT VISION GOGGLE PREFLIGHT AND POSTFLIGHT PROCEDURES

300. SCOPE

This chapter will introduce the AN/AVS-9 Night Vision Goggle (NVG) system, describe its associated components, and outline setup procedures.

301. NVG PREFLIGHT

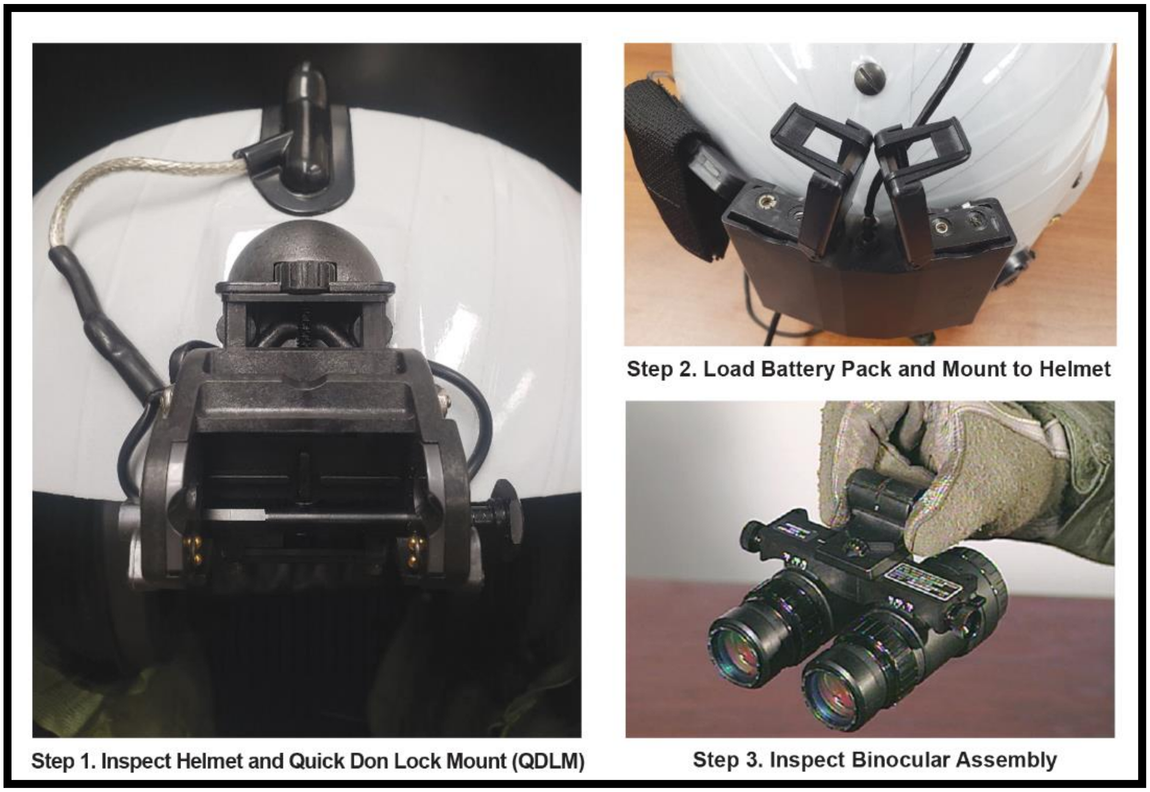
As with any system, the key to achieving the full operational capability of the NVG system is through proper preflight and follow-on postflight care. Ensuring the NVG is properly mounted and adjusted prior to each flight is essential to successful NVG-aided operations. Improper adjustment of goggles can result in not only degraded system performance, but also converging or diverging vision and neuromuscular (accommodative) eye fatigue. This section is dedicated to those procedures critical for NVG sensor optimization.

- **NVG Adjustment and Assessment Procedures**

  - **Step 1. Inspect Helmet**. Inspection of the helmet should be the same as for unaided flight. However, particular attention should be paid to helmet fit due to the extra weight and forward center of gravity caused by the NVG and helmet mount. In addition, inspect the helmet NVG mounting bracket and ensure that it is free and clear of debris.

  - **Step 2. Load Battery Pack and Mount to Helmet**. Prior to inserting the batteries, make certain the power pack is turned off. Ensure the batteries are correctly inserted. The primary battery pack must be inserted into the right side of the power pack and the backup battery pack must be inserted into the left side of the power pack. Attach the power pack to helmet. Connect the power pack cable to helmet mount wiring harness by matching red dots located on each connector and applying fingertip The primary battery pack must be inserted into the right side of the power pack and the backup battery pack must be inserted into the left side of the power pack. Attach the power pack to helmet. Connect the power pack cable to helmet mount wiring harness by matching red dots located on each connector and applying fingertip pressure.

  - **Step 3. Inspect Binocular Assembly**. Ensure there is no obvious damage to either monocular housing. The monocular housings are attached to the position adjustment shelf (PAS), which is constructed of a lightweight plastic material. Consequently, each monocular may move independently of the other, but the movement should not be excessive. Rotate the objective and eyepiece or diopter focus controls to ensure freedom of movement. The diopter controls are naturally “sticky” in their travel due to a plastic-on-plastic design; however, if the controls are very difficult to turn, notify maintenance. In some instances, maintenance can simply release some of the nitrogen pressure and the controls will loosen. Test all other adjustment controls for free movement and smooth operation. In addition, ensure all adjustment knobs and levers are free from dust, dirt, and grime.



Step 1. Inspect Helmet and Quick Don Lock Mount (QDLM)

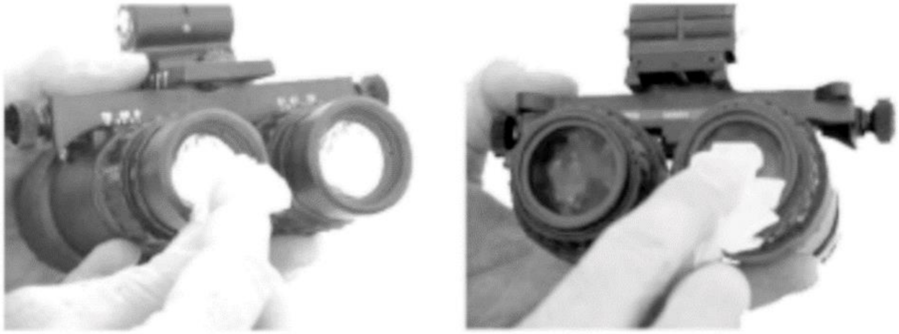
Step 2. Load Battery Pack and Mount to Helmet

Step 3. Inspect Binocular Assembly

Figure 3-1 NVG Inspection and Adjustment Procedures (Steps 1 through 3)

- **Step 4. Inspect Lenses**. Inspect the objective and eyepiece lenses for smudges, debris, scratches, or other damage. Lenses shall only be cleaned by maintenance personnel. ***Do not clean lenses with flight suit, t-shirt, or other materials*****.** USAF data has demonstrated that a single thumbprint on one of the lenses may degrade visual acuity by as much as 30 percent. If the lenses become smudged following preflight the lenses may be cleaned ***only*** using approved lens paper (provided in the NVG case).

- **Step 5. Preset Eyepiece or Diopter Adjustment Ring**. All aircrew requiring corrective lenses shall wear either contacts or glasses while using NVGs. While the convenience of contacts may be preferred by many, some aviators prefer glasses due to drying of the eyes caused by an increase in airflow when flying with NVGs without a visor. Initially, aircrew should set the diopter on each monocular to zero. This will help ensure the resolution chart will be initially viewable when beginning the focusing procedures.



4. Inspect and Clean Lenses (Objective Lenses and Eyepiece Lenses.)

5. Preset Eyepiece or Diopter Adjustment Ring to “Zero”

Figure 3-2 NVG Inspection and Adjustment Procedures (Steps 4 and 5)

- **Step 6. Preset Fore-and-Aft or Eye Relief Adjustment**. Eye relief is the distance between the NVG eyepiece lens and the eye. Eye relief adjustment is made with the fore-and-aft adjustment knob on the AN/AVS-9. Initially, position the binocular assembly as far forward (away from the helmet mount) as possible. This will avoid damage to spectacles (as applicable) and placement of oil on the lens from eyebrows or eyelashes when the NVGs are initially attached to the mount and rotated into the down/locked operating position.

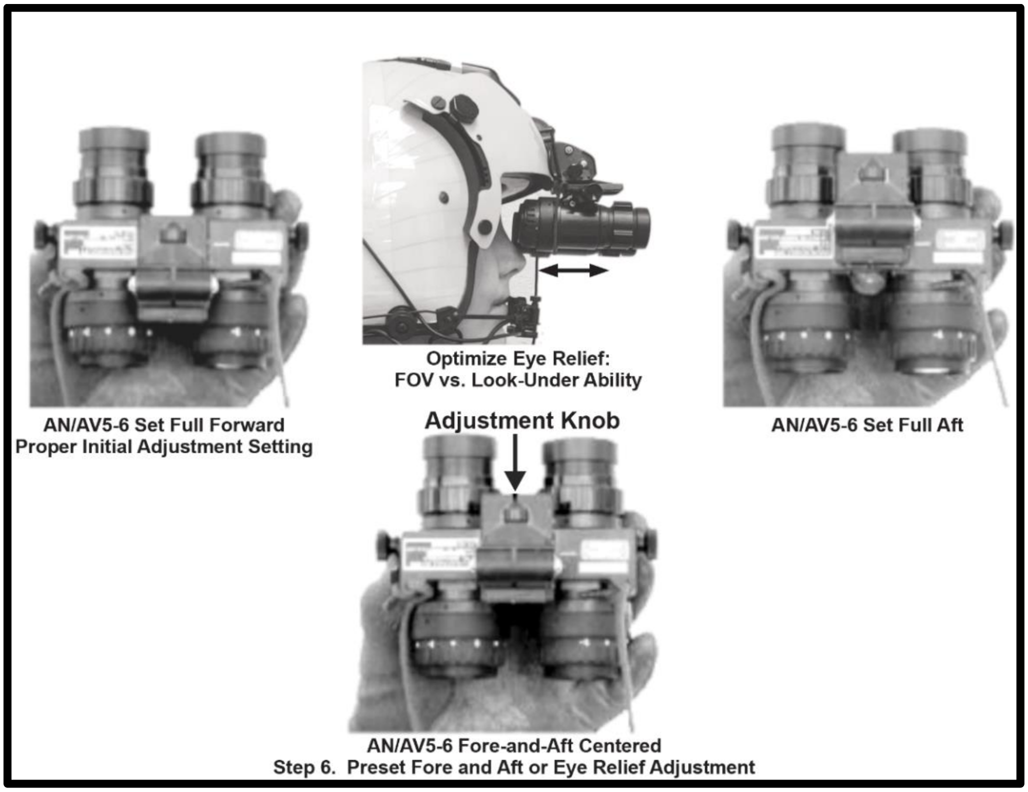


Figure 3-3 NVG Inspection and Adjustment Procedures (Step 6)

- **Step 7. Center Tilt**. Initially set the tilt adjustment to the centered position (determined by aligning the tilt lever with bottom portion of the bridge). Ensure the IPD adjustments do not move when manipulating the tilt lever.

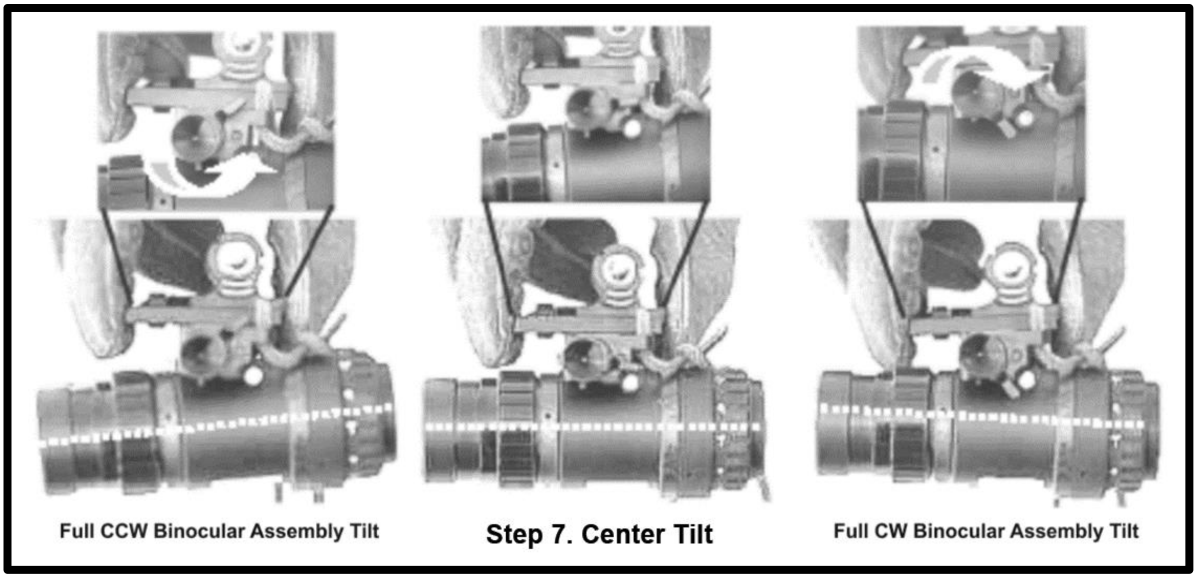


Figure 3-4 NVG Inspection and Adjustment Procedures (Step 7)

- **Step 8. Set IPD**. Rotate the IPD thumb wheels to ensure the mechanisms move freely and the tilt lever does not move as the monoculars track along the bridge. Initially, center the IPD for each monocular.

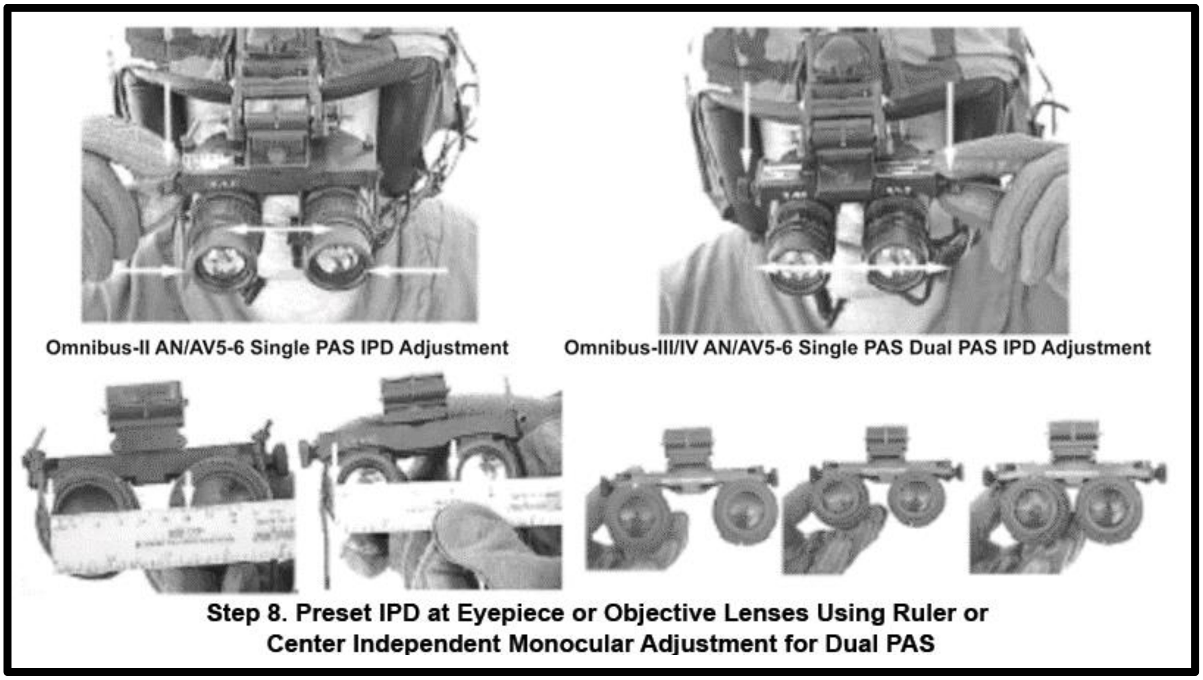
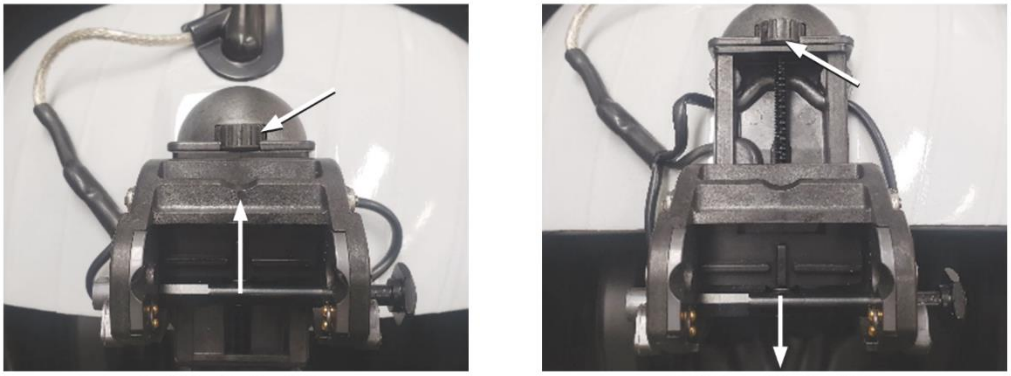
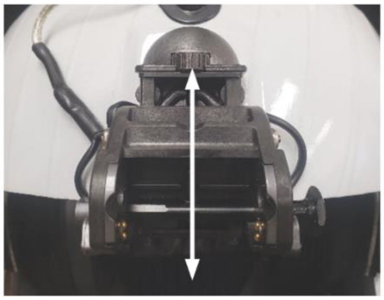


Figure 3-5 NVG Inspection and Adjustment Procedures (Step 8)

- **Step 9. Adjust Vertical**. Ensure the adjustment mechanism located on the NVG mount tracks smoothly to the upper and lower limits of movement, and the thumb wheel moves freely. Set the adjustment to the centered position.



Full Up Vertical Throw Full Down Vertical Throw



Step 9. Center Vertical Adjustment

Figure 3-6 NVG Inspection and Adjustment Procedures (Step 9)

- **Step 10. Don Helmet**. The helmet should be donned in order to check for comfort and to prepare for attaching the NVG. Fasten and adjust the integrated chin/nape strap. This is to ensure no additional adjustments will be required in the cockpit due to a shift in helmet position when the mask is attached.

- **Step 11. Attach and Remove Binocular Assembly**. Attach the binocular assembly to the helmet mount assembly by holding the AN/AVS-9 in a vertical position (90° or perpendicular to mount), as shown in Figure 3-7. Align the spring loaded bearings of the binocular assembly with the channels on the Quick Don Lock Mount assembly shelf and push gently until the binocular assembly snaps into place. Do not exert excessive force. If too much force is required, it is an indication that the bearings are not properly aligned and the binocular assembly may fail to seat properly or become jammed in the mount.

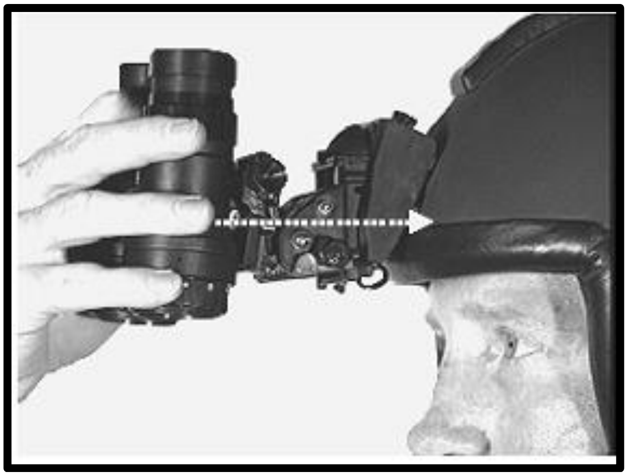


Figure 3-7 NVG Binocular Assembly Mounting

- Ensure the battery switch is in the OFF position before continuing the inspection.
- Do not release the binocular assembly until confirming it will lock securely in the up/stowed position. This action confirms two important points:
  - The binocular assembly is properly seated in the mount.
  - The binocular assembly has not been mounted backwards.
- Once the binocular assembly has been properly seated, press the lock release button and rotate the assembly into the down/locked (ready for flight) operating position. The eyepiece lens (diopter adjustment) should now be closest to the eyes.
- Begin removing the binocular assembly by pressing the lock release button and turning the binocular assembly to the intermediate vertical position. Once out of the locked position, the lock release button can be released. Pull the binocular assembly straight out of the mount, preferably using both hands. Pulling one side slightly out of the detent (slight rocking) and then pulling forward on the assembly may help to remove the NVG easily.
- Practice donning and doffing the AN/AVS-9 binocular assembly until comfortable with the technique.

302. ALIGNMENT PROCEDURES

In a binocular helmet mounted system such as the AN/AVS-9, there are two images, one for each eye. The two images may differ due to horizontal and vertical alignment error or due to differences in the intensified images. Proper alignment is important because best visual performance is possible only when the optical axis of the NVG is perfectly aligned with the visual axis of the eye, as seen in Figure 3-8. Therefore, optimum focus cannot be attained until proper alignment has been accomplished. Ideally, the ANV-20/20 (Hoffman Box) should be used for these procedures. Alignment errors may result because the two optical axes are not parallel. Some imperfection can be present without appreciable adverse effects; however, aircrew should strive for attaining a 100% overlapped circular image sight picture through proper alignment of the NVG axis with the visual axis of the eye. Aircrew should perform the AN/AVS-9 NVG alignment procedures in the following order:

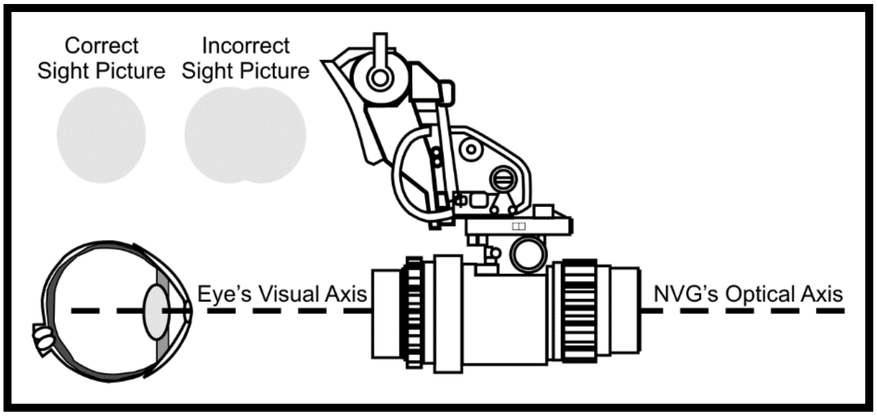


Figure 3-8 NVG Alignment and Sight Picture

- **Step 1. Goggles.** Standing in front a powered Hoffman box, rotate the goggles from the stowed position down to the operating position using the lock release button.

- **Step 2. Power.** Turn on the power pack to the primary ON position, a green glow should be seen. Disregard focusing at this time; it is actually better to have the objective lens out of focus for this procedure.

- **Step 3. Vertical Adjustment.** Vertical adjustment and tilt are important factors for proper NVG monocular alignment with the eye. If not properly aligned with the eye, the upper or lower portion of the FOV will be reduced and the viewer will see the inside walls of the tube. Poor alignment can also result from a defective NVG, poor helmet, or helmet liner fit. Adjust the vertical position of the binocular assembly using the vertical adjustment control located on the Quick Don Lock Mount. The binocular assembly should be set directly in front of the eyes. Using the vertical adjustment knob, move the goggles so the images appear circular and roughly centered. If the googles are too high, the top edges (from 10 to 2 o'clock) of the viewed image will be clearer than the bottom edges (from 4 to 8 o'clock). If the googles are too low, the bottom edges will be clearer than the top edges. Move the goggles in the direction of the blurred edges until both the top and the bottom edges are clear.

- **Step 4. Tilt Adjustment.** Adjust the tilt so the optical axis of the binocular assembly is perfectly aligned with the visual axis of the eyes. If the upper or lower edges of the image areas are blurred, adjust both the vertical adjustment knob and the tilt lever until the blurred edge is removed and an optimal view out to all edges is achieved. Changes in tilt usually require a correction in the vertical adjustment, and vice versa.

Tilt should also re-adjusted in the aircraft. When the tilt angle is adjusted for individual seating position, the vertical height of the google optical axes will change and a corresponding vertical adjustment on the helmet mount assembly will be required.

- **Step 5. Fore-and-Aft or Eye Relief Adjustment.** The recommended eye relief for the AN/AVS-9 is 25mm. This value may not be achievable due to helmet or helmet liner configurations and some anthropometric facial features, such as deep-set eyes or protruding foreheads. If the NVGs are brought in too close to the eyes, the ability to look under the NVGs to read instruments or maps is impaired and an unnecessary strain may be placed upon the eyes. However, if the NVGs are too far away, a significant loss of FOV can occur. To adjust, move the binocular assembly closer to the eyes (Figure 3-9). As the binocular assembly is brought aft, aircrew should see an increase in FOV. Particular attention should be focused on the periphery of the intensified image. The stopping point for adjustment is when one no longer sees an increase in FOV with movement of the binocular assembly aft. As discussed earlier, eye relief should be positioned to maximize the FOV without unnecessarily reducing the ability to see around the NVGs to view cockpit displays or perform other tasks. It is especially important that the NVGs never be positioned so close to the face that the eyepiece lenses contact spectacles or eyelashes.

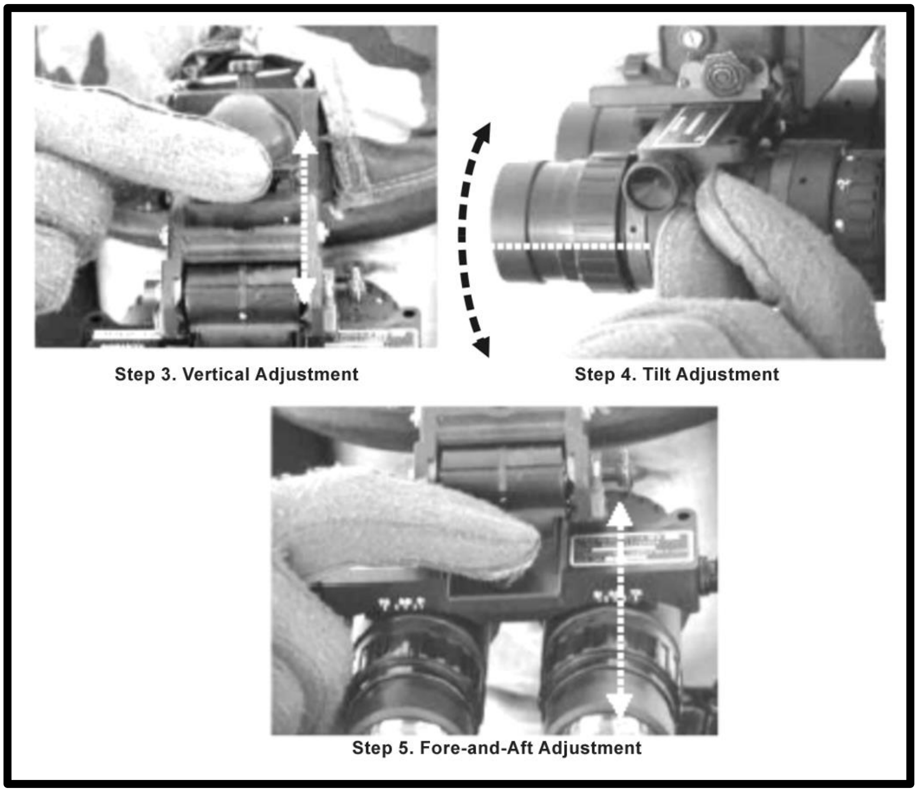


Figure 3-9 AN/AVS-9 Alignment Procedures (Steps 3 through 5)

- **Step 6. IPD Adjustment.** IPD is the distance between the pupils of the eyes. It is also referred to as eye span. The center of the intensifier tubes should be aligned with the pupil of the eyes. The distance between the centers of the tubes should be equal with the user's IPD. If the tubes are not aligned, the eyes tend to drift towards the center of the tubes where the optics provides the best visual acuity. This leads to focusing problems, visual fatigue, and headaches. It has also been attributed as the cause of short-term post-flight reduction of near depth perception. IPD is adjusted with the IPD adjustment knob on the AN/AVS-9, which ranges from 51-72 mm. While adjusting the IPD, one should align each NVG monocular independently in front of each eye. Close or cover one eye and center the image in front of the other eye. Carefully evaluate each monocular image for clarity of the edges bordering the circular intensified image. Repeat for the opposite eye. With both eyes open, evaluate the two monocular images. Observe closely the clarity of the combined edges of the overlapped NVG intensified image. If the outside edges are blurred, the monoculars are too close together and you should increase the separation. If the inside edges are blurred, the monoculars are too far apart and you should reduce the separation. When properly adjusted, the edges of the images in both monoculars will be clear and the resultant NVG intensified image will appear as a single 100% overlapped circle.

Omnibus-II IPD Alignment

Omnibus-III & IV IPD Alignment
Step 6. Interpupillary Distance (IPD) Adjustment

Figure 3-10 NVG Alignment Procedures (Step 6)

- **Step 7. Evaluate the NVG image.** When the goggles are correctly aligned, there should be no shading of any part of the image. If shading is present, attempt to eliminate it by making adjustments in the direction of the shading. If there is insufficient travel in the goggle adjustments, move the entire helmet in the direction of shading. If you must move the helmet in order to achieve proper alignment, it is an indication the mount assembly is not properly positioned on the helmet. Notify the Paraloft so the problem can be corrected.

303. ANV-20/20 NVG INFINITY FOCUS DEVICE – THE HOFFMAN BOX

The ANV-20/20 NVG Infinity Focus Device (Hoffman Box) is a compact portable system designed to provide aircrew an accurate means of performing a quantitative preflight NVG alignment and infinity focus adjustment capability.

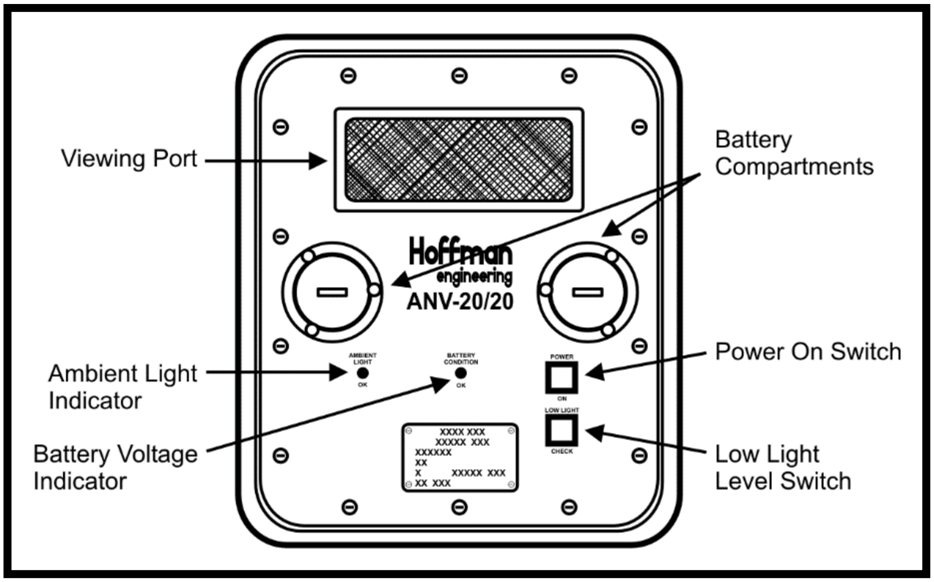


Figure 3-11 ANV-20/20 NVG Infinity Focus Device Front Control Panel

1. ANV-20/20 NVG Infinity Focus Device Operation

Two push buttons and two LED indicators located on the front panel control operation of the ANV-20/20. Depressing the power-on pushbutton activates the unit for a three-minute operation cycle. By holding the power-on pushbutton, the status indicators activate to evaluate both battery condition and ambient room lighting. The green Battery Condition OK indicator will light when battery voltage exceeds 4.2 volts (1,500/3-minute operational cycles). If the indicator fails to light, the batteries should be replaced. To optimize ANV-20/20 operation, ambient room lighting should be minimized. The green Ambient Light OK indicator will not light when ambient light entering the viewing port exceeds 0.1 foot-candle, thereby alerting the operator to reduce ambient lighting prior to operation.

2. ANV-20/20 NVG Infinity Focus Device Operational Modes

The ANV-20/20 can operate in two modes: Normal and Low Light. The Normal Mode, or high light test level is equivalent to viewing a medium contrast target under quarter moon illumination and should be used for the critical NVG preflight focus and adjustment. By looking through the viewing port, aircrew can observe the ANV-20/20 Snellen Visual Acuity (SVA) test pattern that has been set at optical infinity. The test pattern contains nine test targets (grids) that range from 20/20 SVA to 20/70 SVA. Each test target has two sets of vertical and horizontal test pattern grids. If one can resolve both the horizontal and vertical test patterns associated with that test target grid, the individual has achieved that level of SVA. For example, test grid "35" is equivalent to a SVA of 20/35, etc. The test grid fills approximately ten degrees of the NVG FOV. After the operator has achieved the best focus possible using the Normal Mode, the Low Light Mode can be used to gain perspective on anticipated LLL (starlight) NVG performance. Depressing and holding the Low Light pushbutton activates the Low Light Mode. No focus adjustments should be attempted while viewing the SVA test pattern in the Low Light mode.

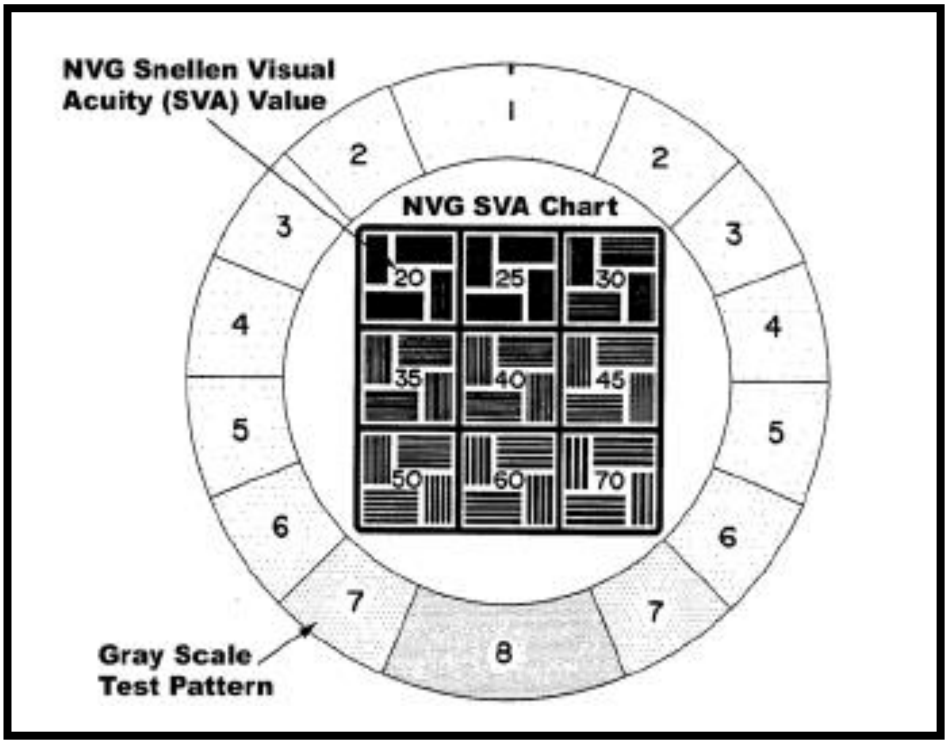


Figure 3-12 ANV-20/20 NVG Infinity Focus Test Pattern

In addition to the SVA test pattern, the ANV-20/20 incorporates a circular eight step gray scale used for evaluating the dynamic gain range of the NVG. The eight successive steps between the brightest pattern #1 (clear) located at the 12 o'clock position and the darkest pattern #8 (black) located at the 6 o'clock position represents the dynamic range of the scale. Each progressive step from #1 to #8 (clockwise or counterclockwise) represents a half decrease in brightness (e.g., quarter moon to eighth moon, etc.). Note that this scale has never been validated and should only be used as a tertiary guide for NVG performance.

304. FOCUS PROCEDURES

Common methods used to focus and adjust NVGs, such as focusing on a small light source or lettering on a nearby aircraft on the flight line, are not sufficient to ensure the NVGs are properly adjusted for flight. The ANV-20/20 provides a simple method to accurately adjust and focus NVGs. The system is inexpensive and provides a standard to assess NVG tube performance and the ability to properly adjust and focus the NVGs. To perform a preflight quality assurance check of the NVGs, each tube must be checked individually and then the two tubes checked together. When viewing the NVG visual acuity targets (e.g., ANV-20/20, NVG eye lane, etc.), the objective is to be able to discern the orientation of the grid lines as being either vertical or horizontal. Not every line in the grid may be perfectly clear, but the direction of the lines should be readily apparent. Start by using the coarser grids (larger lines); try not to initially focus on the finer grids until the eyepiece or diopter lens adjustment has been made. Aircrews should use the following sequential procedures while adjusting the NVG focus:

- **Step 1. Objective Focus.** Ensure the diopter lens (inner ring) is preset to either zero or your known diopter setting. With one eye closed or one tube covered, turn the objective lens (outer ring) of the monocular housing while viewing one of the coarser grids of the NVG visual acuity chart. Attempt to bring the coarse lines into focus. Do not spend a great amount of time with this initial objective lens focus, as the purpose is to obtain an image that is adequate to facilitate a suitable diopter adjustment.

- **Step 2. Eyepiece or Diopter Lens.** Turn the diopter focus adjustment (inner ring) counterclockwise (toward “+” diopter) until the image is blurred. Pause for one to two seconds to allow the accommodative eye muscles to relax, then turn the diopter adjustment clockwise until the image just comes into sharp focus - STOP. If one continues clockwise rotation of the diopter focus ring past the initial point of sharp focus, a range will be seen where the image still maintains clarity. Rotating the diopter adjustment beyond this point, forces the eye muscles to actively work to keep the image focused. During the course of an NVG mission, these eye muscles will become fatigued and unable to maintain this accommodative focus. Do not leave the diopter adjustment beyond the point at which the image initially becomes sharply focused, even though the image remains clear. This will result in an insidious and gradual loss of NVG resolution and depth perception that may not be perceivable to the aircrew. In addition, this maladjustment may also induce severe eyestrain and/or headache. Performed correctly, this procedure focuses the image on the retina of the eye without accommodative muscular effort.

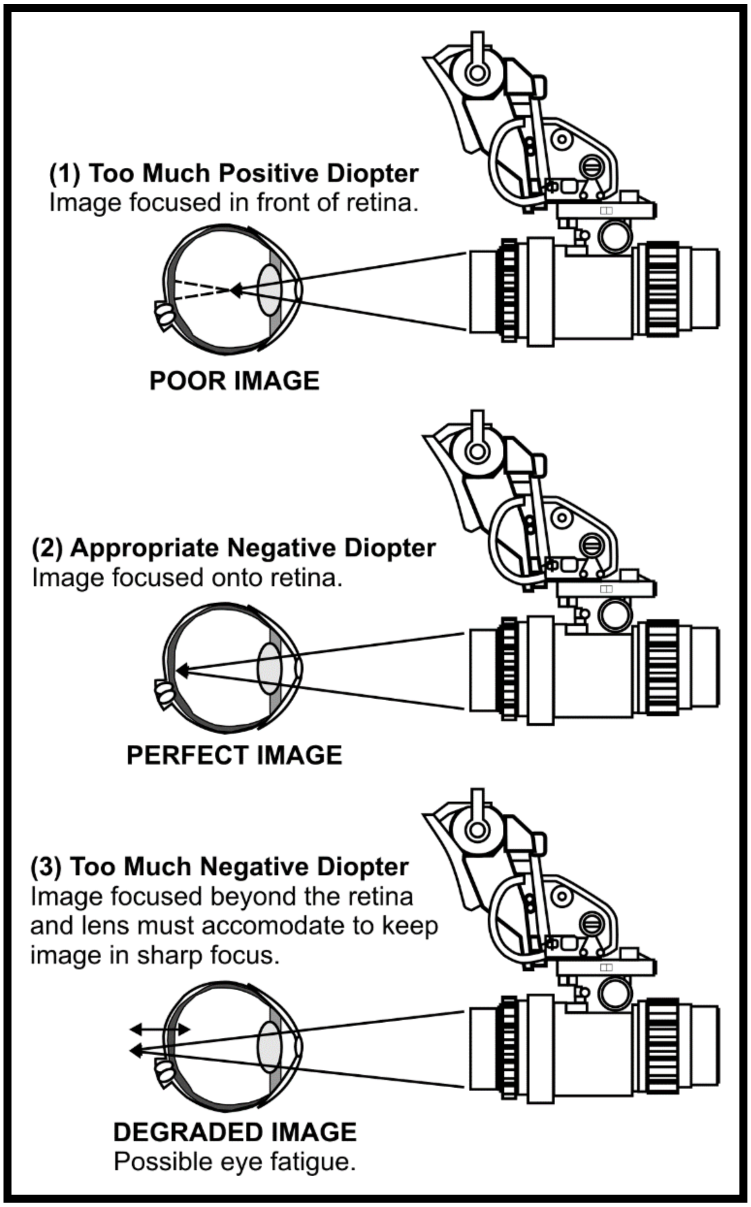


Figure 3-13 Optimal Eyepiece or Diopter Adjustment

To summarize, the diopter adjustment is the most critical adjustment of the NVG. Unfortunately, it is also misadjusted the most often. Follow these procedures to ensure a proper diopter adjustment.

- **Step 1. Rotate counterclockwise beyond the point of focus.** The eye cannot accommodate in this direction, which allows the eye muscles to relax.

- **Step 2. Rotate clockwise, dialing in negative diopter until the best image is achieved.** Assume that you will “overshoot” the optimal diopter setting.

- **Step 3. Rotate counterclockwise until the quality of the image just begins to degrade.** Then nudge the image back clockwise slightly to achieve the optimal diopter setting.

- **Step 4. Readjustment of Objective Focus.** Once the diopter has been adjusted, fine-tune the focus by readjusting with the objective adjustment to bring into focus as many of the grids as possible. This accomplishes two things. First, it assures aircrews the diopter adjustment has been satisfactorily performed. Second, it allows for an accurate assessment of NVG performance. At first, it may take several attempts going back and forth between the diopter and objective adjustments to obtain the best focus. However, once comfortable with the procedure, focusing can be accomplished accurately and consistently with ease.

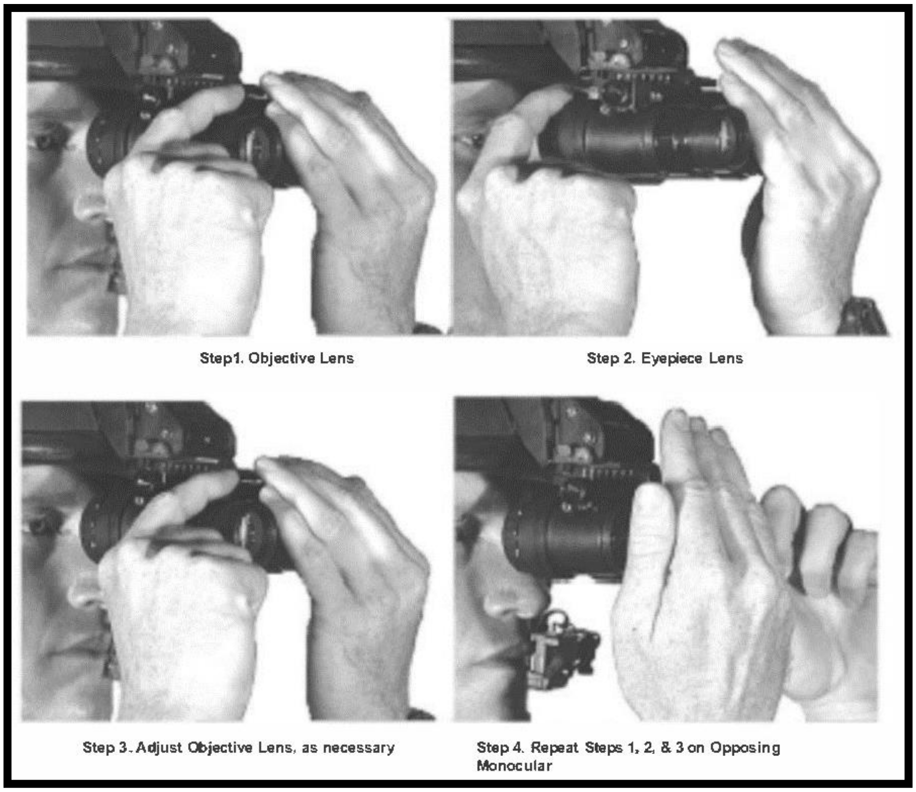


Figure 3-14 NVG Focus Procedures

- **Step 5. Focus of Opposite Monocular.** After focus of the first monocular is accomplished, use the same procedures to focus and evaluate the remaining monocular. Do not be concerned if one monocular image is slightly sharper. A slight difference in the performance of individual I^2 tubes is common.

305. NVG IMAGE ASSESSMENT PROCEDURES

Assessment of the NVG image serves as the quality assurance step for preflight of the AN/AVS-9. With experience, these procedures can easily be integrated into alignment and focusing phases of the NVG preflight.

1. Preflight Focus Adjustment

NVG performance is optimized through proper preflight focus and adjustment. Using a standardized preflight method, rather than a field expedient method, allows you to quantify the performance of the NVG to a known standard. In addition, during low-light level nights, aircrew will not be able to achieve an NVG image that would be suitable to conduct focus adjustments in the field. By using the ANV-20/20, a NVG resolution chart is placed at a known or calibrated distance and illuminated by a high-light level source to present an optimal target for initial NVG preflight alignment and focusing.

2. Evaluate NVG Visual Acuity

NVG visual acuity obtained with both eyes should be at least as good as that obtained through either monocular. If this is not the case, the NVG should be returned and another pair obtained. The minimum NAVAIRSYSCOM acceptable NVG visual acuity for the AN/AVS-9 is 64 lp/mm, which corresponds to the Snellen Visual acuity of 20/25 while viewing a high contrast target under high illumination conditions. Although military specifications require a visual acuity of 20/25, it is important to remember that it is obtained under laboratory conditions. One’s obtainable resolution may differ slightly, particularly when combined with a dirty or scratched canopy, incompatible light sources, and fatigue issues.

3. Evaluate Image Quality

NVG have historically been very reliable. However, the manufacturing process, especially with regard to intensifier tube development, is tedious and susceptible to errors. The following describes potential NVG image anomalies or peculiarities. In some instances, these intensified image peculiarities are normal NVG image nuances, while others are defects. It is important to know the difference to correctly diagnose the image peculiarity and to better write the NVG Maintenance Action Form, if warranted. The most common image peculiarities are listed below and depicted in Figure 3-15.

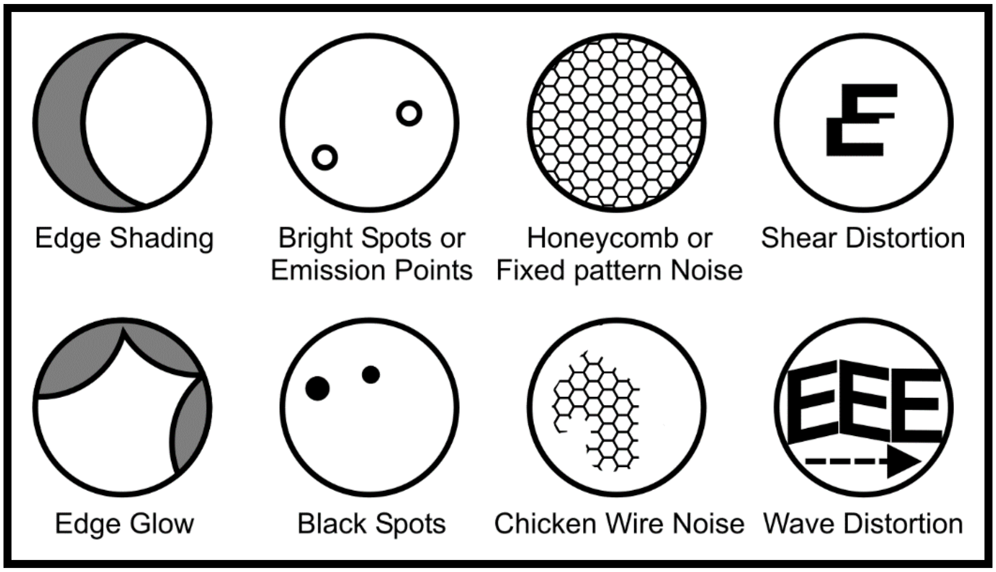


Figure 3-15 Image Defects

4. **Shading**

Each monocular should present a perfect intensified image circle. If shading is present, you will not see a full circular image. It appears as a dark area along the edge of the image. Initially, try readjusting the controls (e.g., Tilt, IPD, and Vertical Adjustment) by moving the individual monocular toward the area of shading. If the shading persists, try moving the NVG and/or helmet toward the shaded edge. Uncorrectable shading is indicative of a dying photo-cathode caused by a defective vacuum seal on the image intensifier tube. Shading is very dark and one cannot see an image through the shaded region of the intensifier tube. Shading will always begin on the edge and will eventually move inward across the entire image area. The shaded region will also present a high contrast and distinct line of demarcation. Do not confuse shading with variations in output brightness. If uncorrectable shading is present, turn the NVG in to maintenance.

5. **Edge Glow**

Edge glow appears as a bright area along the outer edge of the image. It is usually the result of an incompatible light source within or just outside the NVG FOV, although, it can also be the result of an I^2 tube's micro-channel plate shift induced by mishandling. If detected, simply cup your hand over the objective lens to block out all light. If the image still displays edge glow, the bright area will still show up. If the edge glow does not disappear, turn the AN/AVS-9 in for maintenance.

6. **Image Flickering**

Flashing, flickering, or intermittent operation of the NVG may reflect an impending failure of the tube, dirty electrical contacts, faulty wiring, or battery. This can occur in either one or both monocular. If there is more than one flicker, check for dirty contacts, loose wires, loose battery cap, or weak batteries. If corrective action does not alleviate the condition, turn the NVG in for maintenance. If airborne, switch to the alternate battery and assess NVG operation.

7. **Bright Spots**

Bright spots can be defects in the image area caused by a flaw in the film on the I^2 tube's microchannel plate. A bright spot is a small, non-uniform, bright area that may appear either as a flicker or as a constant output. Not all bright spots are downing gripes for the AN/AVS-9. Bright spots usually go away when light is blocked from the objective lens and are considered cosmetic defects that are signal induced. To determine the significance of the bright spots, cup your hand over the objective lens to block out all light. If the bright spot(s) remain, turn the NVG in for maintenance. Bright spots can be acceptable if they do not interfere with the aircrew's ability to view the NVG Image. NVG specifications limit the size, location, and number of bright spots within the NVG I^2 tube. If the spots are distracting or interfere with the operator's ability to perform the mission, return the goggles for maintenance.

8. **Black Spots**

Black spots can be either cosmetic blemishes in the I^2 tube or dirt/debris between the lenses. Black spots are acceptable as long as they do not interfere with viewing the NVG image. As with bright spots, the NVG specification has guidelines that limit the size, location, and number of black spots within the NVG intensified image field. If the spots are distracting or interfere with the operator's ability to perform the mission, return the AN/AVS-9 for maintenance.

9. **Emission Points**

Emission points are steady or flickering pinpoints of bright light in the NVG image area that do not go away when all light is blocked from the NVG's objective lens. The position of the emission points within the image will not move. Emission points are not necessarily a downing gripe. Emission points become unacceptable if they are brighter than the background scintillation of the I^2 tube under LLL illumination conditions.

10. **Honeycomb Pattern (Fixed-Pattern Noise)**

Honeycomb pattern is usually a cosmetic blemish characterized by a hexagonal (honeycomb) pattern visible across the entire intensified FOV. The honeycomb pattern most often occurs under high light level or when a bright light source is introduced into the NVG FOV. This pattern is a result of the manufacturing process in which the fiber optics is assembled within the tube. Normally it is faint in appearance and does not affect NVG performance. Should it appear as a bold outline or during low-light level NVG conditions, turn the NVG in for maintenance.

11. **Chicken Wire**

Chicken wire is an irregular pattern of dark thin lines in the FOV, either throughout the entire intensified image field or simply in selected parts of the NVG image area. Under the worst-case condition, the lines will form hexagonal or square wave-shaped lines. These lines are caused by defective fibers that do not transmit light at the boundaries of the fiber bundles in the output optic of the I^2 tube. If the chicken wire interferes or distracts the aircrew, return the goggle for maintenance.

12. **Distortion**

Distortion is introduced into an I^2 tube during the manufacturing of the fiber optic twist. This small amount of distortion is not perceivable to the human eye. The two most common types of distortion are wave (or bending) distortion and shear distortion. Wave distortion is when vertical linear objects, such as trees or poles appear to wave or bend when one moves their head. Shear distortion is when static linear objects appear as a misaligned image.

13. **NVG Glare**

NVG glare occurs when light outside the FOV strikes the objective lens of the AN/AVS-9 and scatters instead of passing through the lens. NVG glare produces a decrease in NVG image contrast and appears as a light haze across the entire image. It can be caused by excessively scratched, pitted, or chipped objective lenses. In addition, dust, smudges, or fingerprints may also contribute to this condition.

14. **Scintillation**

Scintillation or image graininess is a normal nuance of the NVG image that occurs as light level decreases. Scintillation appears as a “sparkling” effect over the NVG image and results from electronic noise created at the high gain levels achieved under low illumination conditions. In flight, it can be an indication of decreasing illumination caused by such things as worsening weather conditions or flight into shadowed areas.

15. **Brightness (Luminous) Difference**

During or after making the adjustments for IPD and binocular focusing, one image may appear less bright (dimmer) than the other image. If the difference in brightness is judged great enough to interfere with the mission performance, the NVG should not be utilized.

16. **Contrast Difference**

During or after making the adjustments for IPD and binocular focusing, the two images may differ in contrast. In a contrast comparison, the user is looking for noticeable differences in the range between the darkest and lightest portions of an image. For example, if a highly reflective tree is extremely bright in one tube, and relatively dim in the other, contrast differences may be deemed unacceptable for that set of NVG. This may indicate a defective tube. The user may elect whether or not to utilize the NVG for a given mission after considering ambient light levels, terrain, user experience, and degree of tube differences.

17. **Visual Acuity or Image Disparity**

This condition exists when there is a difference in performance between the two image intensifier tubes within the same binocular. This is usually noted by one monocular attaining a better acuity than the opposing monocular. If the acuity or image disparity is judged to be great enough to interfere with mission performance, the NVG should not be utilized.

CHAPTER FOUR
NIGHT VISION GOGGLE SCENE INTERPRETATION

400. SCOPE

This chapter introduces flight planning considerations for operations in the night environment during both unaided and NVG flights.

401. NVG MAP SELECTION

Initial steps in planning preparation should include assembling maps and imagery. In the Advanced Helicopter Training syllabus, the Joint Operations Graphic (JOG) (AIR) will be the primary maps for NVG navigation. Below is a list of maps and other planning tools you may see here and in your future squadrons. Utilize the procedures covered in the FTI for Low Level Navigation.

1. Joint Operation Graphic (JOG)

The JOG is a 1:250,000-scale map that is normally the primary map for planning and flying the enroute portion of a mission. The JOG is configured with both latitude/longitude markings and UTM grid.

2. Chart Updating Manual (CHUM)

The Chart Updating Manual (CHUM) is a supplementary publication, with bulletins published quarterly, that can be consulted for the most current information on potential low level hazards; towers, power lines, etc. An electronic CHUM is available through JMPS and through the ECHUM website.

402. NVG MISSION PLANNING

1. Route Selection

To help offset difficulties encountered in navigating on NVGs, routes should be planned to be as simple as tactically allowable, preferably in straight lines between checkpoints. The following proven specifics are provided as guidelines for NVG route selection.

2. Cultural Area Considerations

a. Avoid large areas of cultural lighting due to increased halo effect and goggles de-gaining with the end result of loss of scene detail.

b. Anticipate wires, including parallel sets, near roads, towers, and buildings isolated in open fields. Look for associated posts, poles, and stanchions. Flight directly over the poles will aid in obstacle clearance. Unexplained linear cuts in vegetation are also useful in locating wires.

c. Towers may be used for orientation purposes. Avoid towers and do not use them as checkpoints. Towers may be lit with bright lights or LED lights, and may degrade the NVG's capabilities or may not be seen, respectively.

3. Solar and Lunar Considerations

a. Plan to transit large valleys on the illuminated side with respect to the moon's position. This will avoid shadows cast off terrain by the moon that silhouette terrain features for navigation.

b. Avoid a route that heads directly into a low rising or setting moon/sun. If the timing of the launch forces this condition, plan to proceed in a zigzag advance across the route of flight using an approximate 30° offset to either side. This technique should help to counter the degrading influence of either the moon or sun on the NVGs.

4. Checkpoint Selection

After a general route has been determined, checkpoints to control movement along the route must be selected. In selecting checkpoints, the following areas should be considered:

a. Checkpoints should be easily identifiable from the air.

b. Checkpoints should contrast with surrounding terrain by shape, size, color, or elevation.

c. If possible, checkpoints should not be selected near metropolitan areas, since they invariably grow and may alter the checkpoint or make its detection difficult.

d. When possible, a checkpoint should be easy to confirm by association with adjacent prominent features to alert the pilots to its location, i.e., limiting and funneling features.

e. Moon percentage, elevation, and azimuth throughout the course of the flight must be considered. Checkpoints should not fall within the shadow cast by a terrain feature.

f. Select prominent limiting features near checkpoints, particularly where a turn is planned. The limiting feature is used to alert the pilot he has overflown a checkpoint. It is often better to discard a prominent (e.g., easily identifiable) checkpoint with no limiting feature in favor of a less prominent checkpoint with a solid limiting feature.

g. Make note of the MSL altitude of each checkpoint during planning to aid in checkpoint confirmation when flying in mountainous or hilly terrain.

h. Select intermediate reference points between checkpoints to ensure course confirmation and route timing. The lower the ambient light level, the more intermediate the reference points should be used.

The first and last checkpoints of a route are the most important. An easily identifiable feature must be utilized for both of these, even if a route must be altered slightly.

403. MISSION EXECUTION

Advanced Helicopter Training NVG syllabus flights are flown at relatively higher altitudes than the low-level navigation syllabus events. NVG events should be planned at 100 knots ground speed.

1. **Crew Resource Management**

   a. PAC utilizes primarily an outside scan with a BI cross-check for altitude, airspeed, and heading (NVG Integrated Scan).

   b. PNAC is primarily responsible for navigation and backing up the PAC.

   c. PNAC is responsible for all radio and avionics manipulation, to include radio calls unless otherwise delegated.

   d. Either pilot can call for power in an unsafe situation.

   e. PNAC should be directive then descriptive when providing navigational inputs to the PAC.

2. **Amplification and Technique**

   a. PNAC gives a clock code position for a turn and then calls for a rollout once on correct heading.

   b. PNAC can provide PAC with an aim point in the distance or on the horizon to aid with aircraft heading.

   c. Utilize the 6Ts or modified 6Ts at each checkpoint as a memory aid for timing checks, radio calls, etc.

   d. PNAC aids PAC by describing the checkpoint and/or important features along the route that PAC should be looking for or aware of.

   e. Placing frequency or squawk changes on the chart near the appropriate checkpoints can serve as a memory aid when reaching that area.

3. **Common Errors**

   a. PNAC not calling out clock codes, rollout headings or providing direction to the PAC.

   b. Failing to initiate CTAF calls or switch to the appropriate frequency.

   c. Not having the appropriate charts for navigation.

d. Failure to utilize good limiting and/or funneling features to identify checkpoints.

e. Failure to utilize NVG considerations for checkpoint identification.

f. Improper or lack of planning that results in a route violating the RWOP, FAR AIM, FTI or read and initial guidance.

g. Failure to account for winds during the navigation phase, including its effects on groundspeed, overall timing, and crab angle to maintain ground track.

h. Lack of or insufficient fuel and gauges checks along route specifically as it relates to Bingo fuel.

i. Failure to account for field closure.

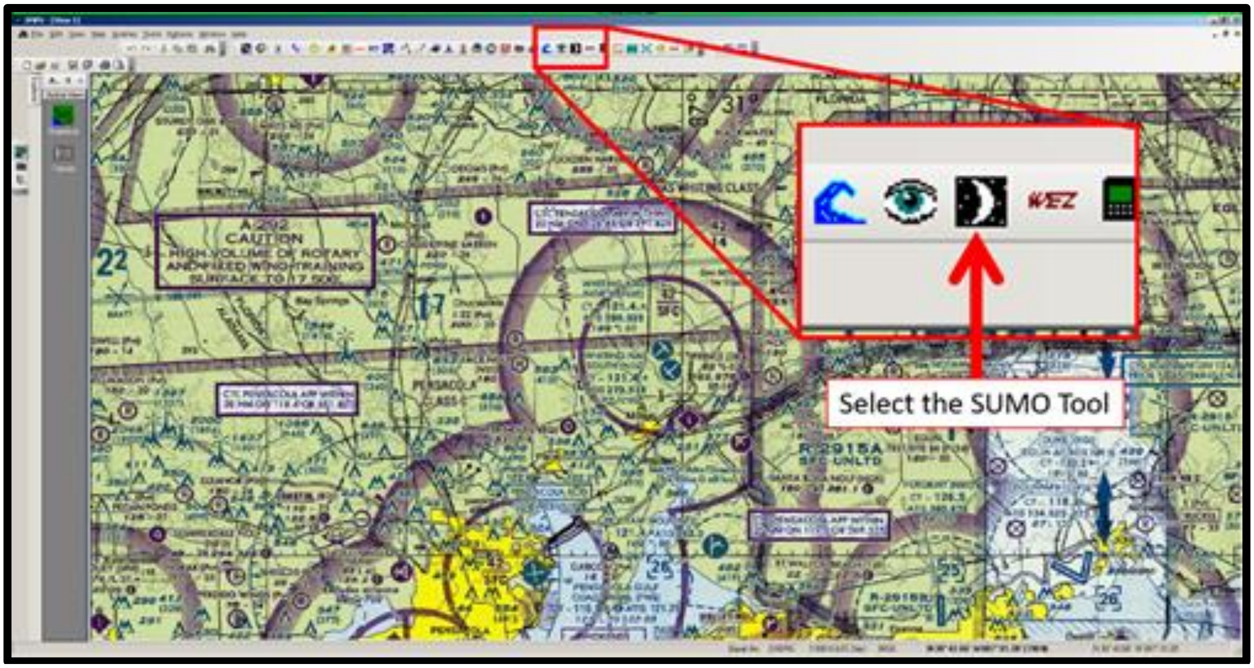
j. Misuse of the lip light by shining around the cockpit and directly at other members of the crew. Consideration should be given to using the Sidewinder flashlight or other NVG compatible light for reading the map or checklist.

404. SOLAR/LUNAR ALMANAC PREDICTION (SLAP) PROGRAM

The ***MAWTS-1 NVD Manual Chapter 2.3.1.2 and Chapter 10.6 and*** discusses the use of the SLAP Program in detail. Particular attention should be paid to Lunar Daily Illumination (LDI) and Lunar Elevation Angle and Azimuth (LEAA) data when planning for flights utilizing NVGs. Amplifying information for LDI and LEAA are found in ***Chapter 10.6.2.4*** and ***Chapter 10.6.2.9,*** respectively. The following section will describe the appropriate methodology for obtaining SLAP data for NVG flights.

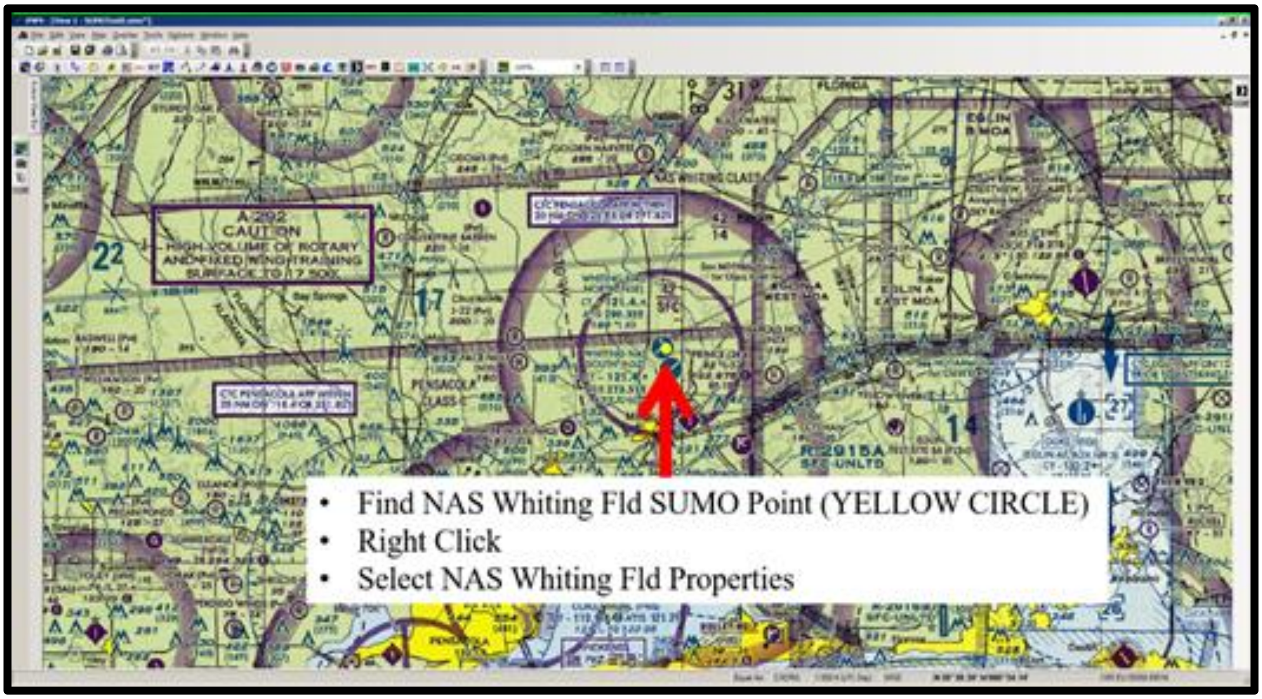
– JMPS SLAP Program Tutorial

The Joint Mission Planning System (JMPS) is the primary method for obtaining SLAP data for flight planning. The SMA shall use the SUMO tool to generate appropriate SLAP data for the mission. This is a tutorial on how to use the SUMO tool with guidance on generating Lunar Daily Illumination (LDI) and Lunar Elevation Angle and Azimuth (LEAA) data. These two charts will provide sufficient information on illumination conditions to be expected during a night mission. The following six figures (Figures 4-1 through Figure 4-6) describe the necessary steps to generate LDI and LEAA data.



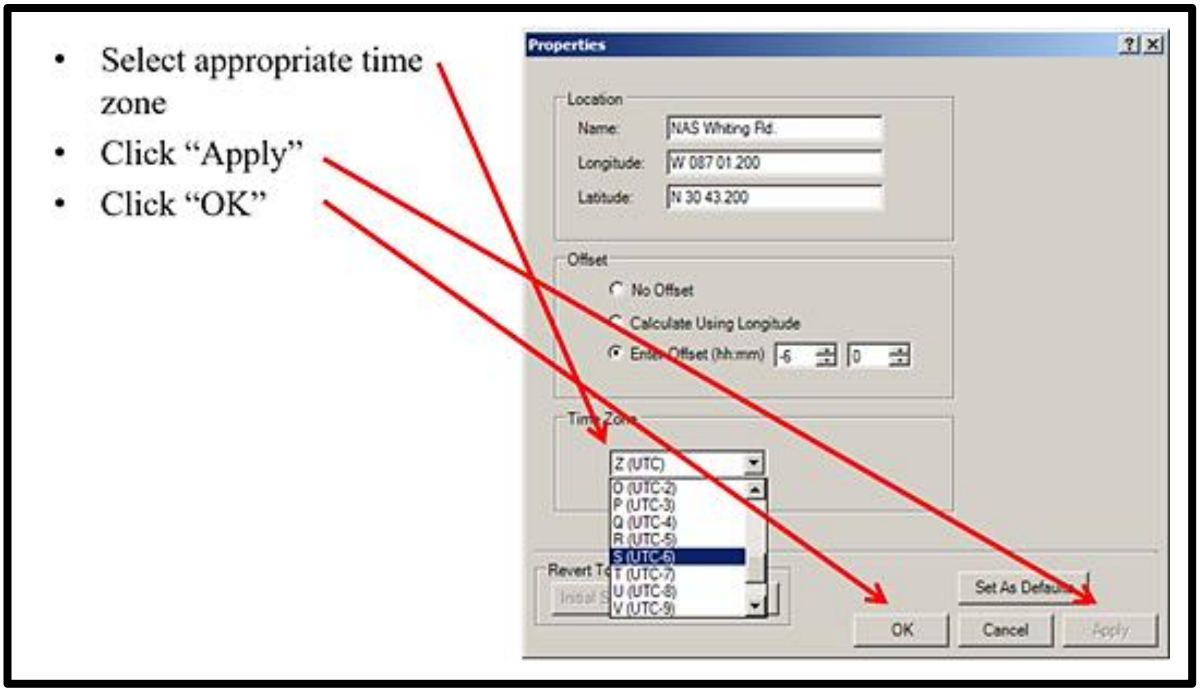
Select the SUMO Tool

Figure 4-1 JMPS LDI/LEAA Step 1



- Find NAS Whiting Fld SUMO Point (YELLOW CIRCLE)
- Right Click
- Select NAS Whiting Fld Properties

Figure 4-2 JMPS LDI/LEAA Step 2



- Select appropriate time zone
- Click "Apply"
- Click "OK"

Properties

Location

Name: NAS Whiting Fld.

Longitude: W 087 01.200

Latitude: N 30 43.200

Offset

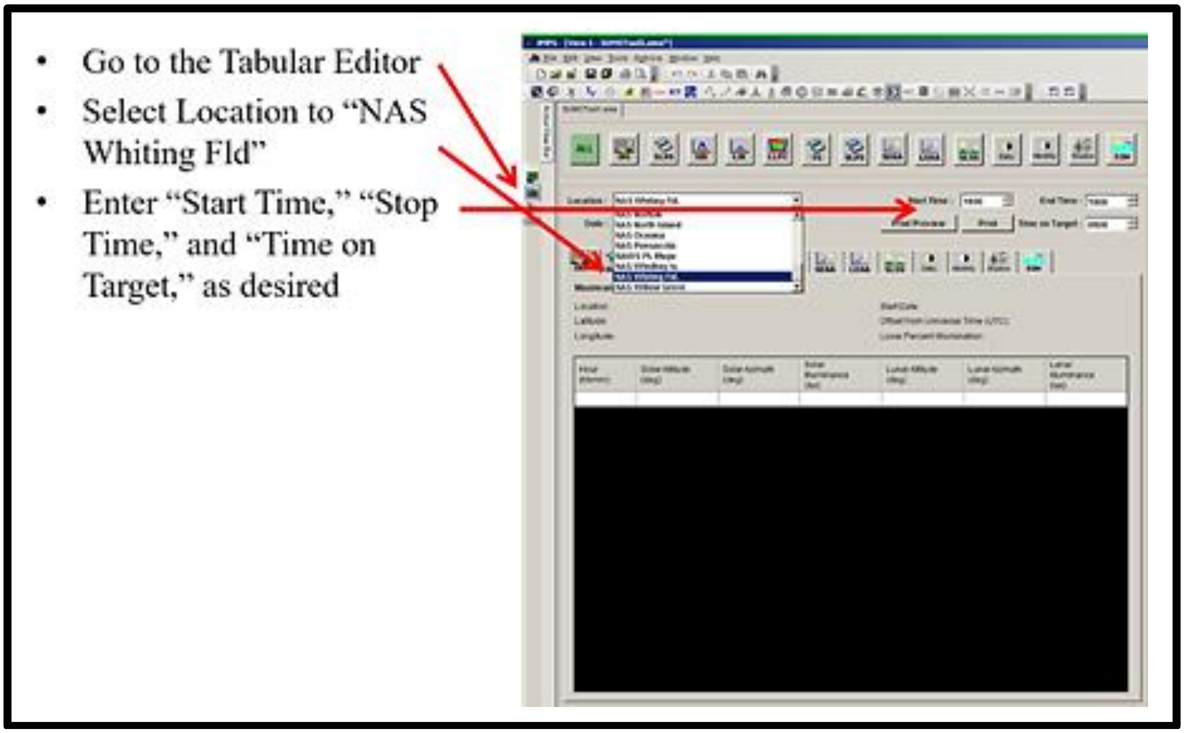
○ No Offset

○ Calculate Using Longitude

● Enter Offset (hh:mm) -6 0

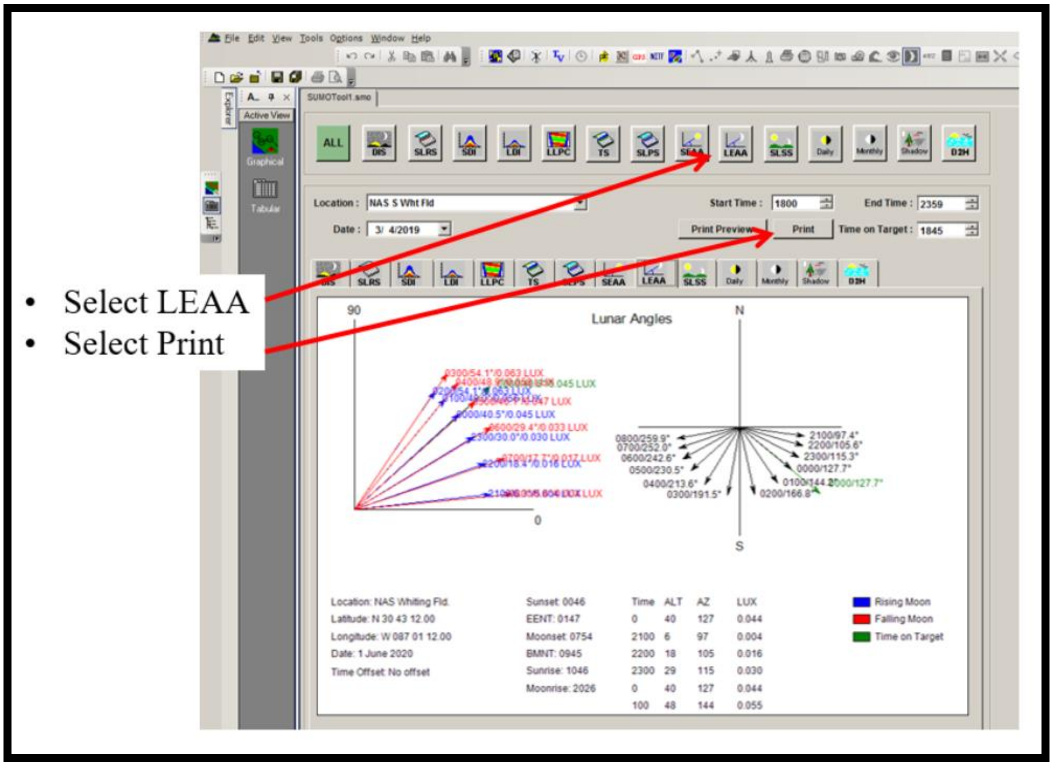
Time Zone: Z (UTC)

Figure 4-3 JMPS LDI/LEAA Step 3



- Go to the Tabular Editor
- Select Location to "NAS Whiting Fld"
- Enter "Start Time," "Stop Time," and "Time on Target," as desired

Figure 4-4 JMPS LDI/LEAA Step 4



- Select LEAA
- Select Print

Location : NAS S Wht Fld
Date : 3/ 4/2019
Start Time : 1800
End Time : 2359
Time on Target : 1845

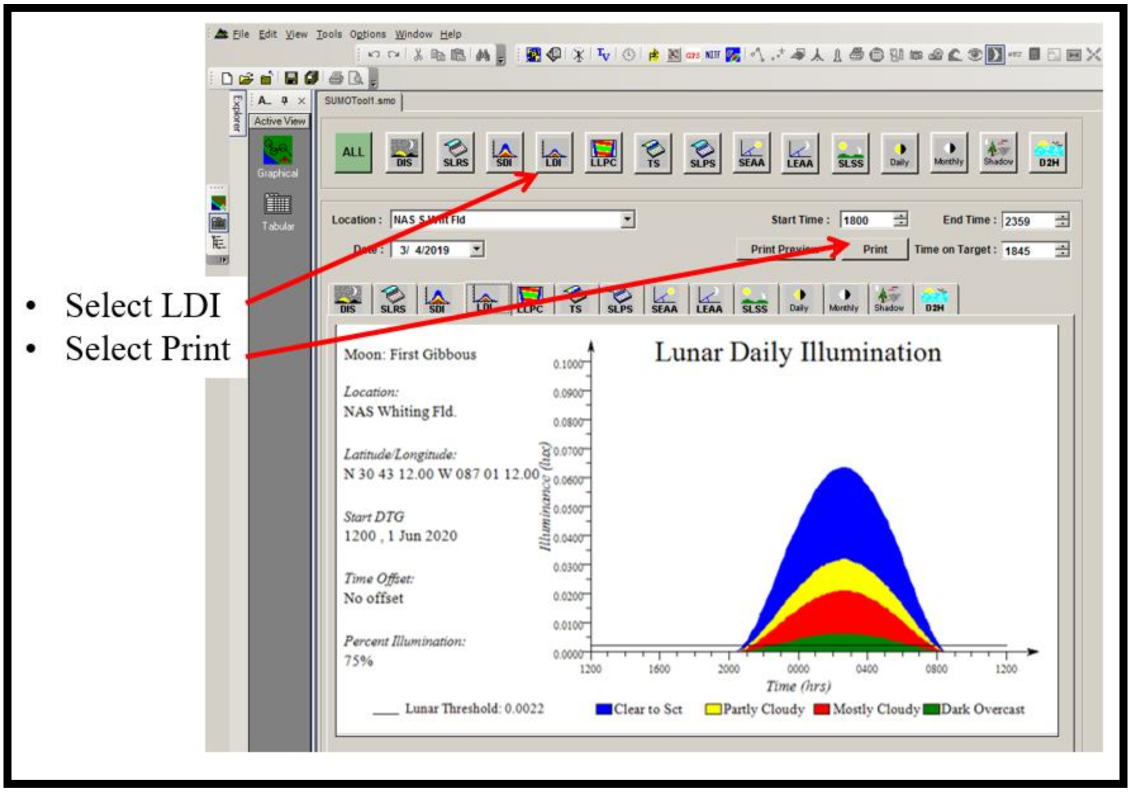
Location: NAS Whiting Fld.
Latitude: N 30 43 12.00
Longitude: W 087 01 12.00
Date: 1 June 2020
Time Offset: No offset

Sunset: 0046
EENT: 0147
Moonset: 0754
BMNT: 0945
Sunrise: 1046
Moonrise: 2026

Time	ALT	AZ	LUX
0	40	127	0.044
2100	6	97	0.004
2200	18	105	0.016
2300	29	115	0.030
0	40	127	0.044
100	48	144	0.055

🟦 Rising Moon
🟥 Falling Moon
🟩 Time on Target

Figure 4-5 JMPS LDI/LEAA Step 5



- Select LDI
- Select Print

Location : NAS S Wht Fld
Date : 3/ 4/2019
Start Time : 1800
End Time : 2359
Time on Target : 1845

Moon: First Gibbous

Location:
NAS Whiting Fld.

Latitude/Longitude:
N 30 43 12.00 W 087 01 12.00

Start DTG
1200 , 1 Jun 2020

Time Offset:
No offset

Percent Illumination:
75%

Figure 4-6 JMPS LDI/LEAA Step 6

405. NVG SCENE INTERPRETATION

1. Terrain Assessment

It is important for night crews to thoroughly study anticipated terrain characteristics to help predict visual performance with NVGs. This assessment can be divided into few basic areas:

2. Density

Density is the relative measure of "how many things on the ground can be seen." An object must have sufficient size and contrast to be distinctly perceived by either central or peripheral vision. Examples of areas with poor density are open areas, completely snow-covered terrain, most deserts, and calm water. Because of the reduction in resolution, contrast, and FOV inherent with NVGs, the terrain density will be perceived to be less than with the photopic eye. The reduction in density increases the potential for spatial disorientation; therefore altitude and airspeed cues derived from terrain density must be crosschecked and verified with cockpit instruments, in particular the RADALT.

3. Terrain Profile

Merely reading the numbers off a RADALT will only ensure terrain clearance for what is directly below the aircraft. The pilot will need to maneuver depending on the type of terrain in front of them as it changes. Terrain profile is the terrain assessment that measures two characteristics of the terrain: terrain gradient and terrain slope.

4. Terrain Gradient

It is the contour of the terrain and can be divided into three broad categories: **flat**, **rolling**, and **rough**. Flat terrain will require the least amount of effort devoted to monitoring the flight path. Rolling terrain will require more effort to be directed toward flight path monitoring due the possible presence of the possibility of hidden hills. Rough terrain will require almost exclusive effort be devoted to flight path monitoring because of the rapid changes in terrain features. The possibility of not seeing hills or other terrain features increases with NVGs because of their contrast limitations and their poor performance in very low illumination conditions, such as terrain shadowing.

5. Terrain Slope

It is the measure of the tilt of the overall terrain. An up-slope will require more effort be devoted to flight path monitoring compared to even or down-sloping terrain. In areas of low-density terrain, detecting gentle up-sloping terrain is very difficult. Turns in these situations are hazardous due to the reduced time available for detecting the up-slope while turning into it. The RADALT is your best means to detect changes in slope. Unfortunately, the RADALT only tells you what was below the aircraft and does not provide rate information. The RADALT also has a roll and pitch limitations making it an unreliable source of information in certain maneuvers. Good mission planning and SA will help reduce the possibility of a mishap.

6. Unseen Vertical Obstructions

The last flight terrain assessment category is unseen vertical obstructions. This category includes anything that sticks up into the aircraft's flight path, such as trees, power lines, antennas, poles, or hidden hills. The reduced contrast, resolution, and FOV provided by NVGs combine to create the potentially hazardous situation of not detecting these obstructions until it is too late. Presently, the best way to cope with this hazard is to maintain up-to-date hazard maps, SA, and extra vigilance when searching.

406. COMMON NVG SCENE DESCRIPTIONS

1. Shadows

Knowing the moon angle and azimuth, combined with a thorough map study, will enhance the capability of the aircrew to use or avoid shadows as necessary. NVG performance is influenced by shadows. NVG shadows are formed by illumination sources (usually the moon) being blocked by terrain or cultural objects. Shadows created by clouds can create visual illusions leading to disorientation. For example, while flying underneath a broken layer on a high light level night, the pilot will be constantly in and out of shadows causing the NVG gain to fluctuate, thereby making it more difficult to pick out terrain features. The changes in illumination will also affect depth perception. A scattered layer will not be as distracting but can mask or hide important navigation or targeting information. In the brighter areas between the scattered cloud layers, the NVG gain will be driven down making it more difficult to see objects lying within the shadows. Once inside the shadowed area, the gain will readjust, perhaps making it easier to see the previously hidden objects. Some shadows can be predicted, such as those cast by towers, smoke stacks, and mountains.

2. Roads

The ability to detect roads with NVGs depends primarily on the albedo difference between the road and the surrounding terrain. Sometimes the road itself will not be seen initially. A swath or cut through a forested area that was cleared for a road might alert aircrew to a road’s presence. A concrete road (quite reflective) should be easily seen in farming country where the surrounding terrain may be less reflective. However, a concrete road may be less discernible in a desert environment where the road and terrain may have similar reflective values. On the other hand, an asphalt road may be more discernible in desert conditions where the albedo difference will likely be much greater. The bottom line is that roads may or may not be easily seen and preflight planning will help reduce surprises.

3. Water

There is very little contrast between a land mass and a body of water during low light conditions. When viewed through the NVGs, lakes or rivers appear dark. As the light level increases and the moon angle decreases, the water begins to change color, land-water contrast increases, and reflected moonlight is easily detected. When overflying large open areas of calm water, reflections from clouds, stars, or the moon can be disorienting. NVGs may be able to display a horizon but, due to the lack of surface texture, height above water may be impossible to perceive. Due to the lack of terrain density, aircrew must rely heavily on flight instruments while flying over open water; however, when a surface wind or swells exist, the resulting whitecaps can provide contrast to assist in altitude and speed estimation.

4. Open Fields

Contrast is very poor in large fields covered with similar vegetation. Leaves containing chlorophyll may appear almost white. A freshly plowed field will likely have little vegetation and the roughened terrain will probably absorb, more than reflect, light energy. This combination will create a darker area. Overflying a series of smaller fields with differing vegetation can help overall situational awareness. Fields with vegetation will usually have high terrain density that aids in orientation.

5. Desert

Most of the time, open desert presents a washed out image through NVGs due to poor contrast and poor terrain density. Gradually rising terrain and ridgelines can be particularly difficult to discern and may first be noted by a change in the RADALT. On a particularly bright night with the moon high overhead, the NVGs can begin to de-gain or wash out considerably, making it even more difficult to pick out what little contrast or density is available. Additionally, fixed pattern noise (honeycomb) may be seen under these conditions creating “focus trapping” (staring at the pattern rather than the terrain) and making it even more difficult to discern small contrast differences. In general, flying above this type of terrain is similar to flying over water (without the reflection) and is best accomplished at a higher altitude or using instrument flight techniques.

6. Forests

Heavily forested areas may not reflect light efficiently and solid canopied forests can appear extremely dark unless the trees have leaves with high levels of chlorophyll (usually in the spring). Excellent contrast and texture differences do exist between deciduous (leafy) and coniferous (pines, firs, etc.) trees.

7. Snow

Fresh, wet snow reflects about 85% of the energy incident upon it thereby providing good natural reflectivity. However, high light levels can provide excessive luminance, which, like the desert, can lower gain and degrade resolution (NVG image washout).

8. Artificial Light Sources

Highly populated areas can generate very significant levels of ambient light. Many of the discrete artificial sources exhibit overlapping halos in the NVG image. This substantially reduces contrast and detail between sources. Although lighted areas can be seen from great distances, specific buildings or objects within the lights cannot always be distinguished. When associated with overcast, city lights can supply increased illumination to less illuminated areas by reflecting light from the bottom of the cloud layer. A baseball field lit up at night can look like a small town. Automobile lights can provide excellent cues to the presence of a road, but direct light from an automobile, especially halogen types, can be very disconcerting at low altitude. The red lights on top of radio and microwave towers are visible from 10-30 miles, depending on the atmospheric conditions, but their range and relative distances can be hard to judge. Aircraft anti-collision lights can be seen at even greater distances. If you must look into the bright light source it may be necessary to revert to instrument flight for brief periods, realizing that maneuverability is adversely impacted during this time.

407. LLL CONSIDERATIONS

The low light level (LLL) environment flight regime is the most demanding environment to operate in. It requires detailed briefing, excellent crew coordination, and a vigilant scan. NVG performance in conditions of low ambient illumination is characterized by decreased resolution, visual acuity, contrast, and hazard detection range. Low ambient illumination also creates an increase in the blooming effect from artificial illumination sources (e.g., aircraft lighting, muzzle flashes, rocket motors, flares, and cultural lighting). This is due to a small amount of light (photons) available to strike the photocathode. Since the photocathode receives much less light, the image has “video noise” commonly referred to as “graininess” or “scintillation.” This situation is similar to television reception with a weak signal. The picture quality will remain poor until the signal (illumination) becomes stronger.

LLL is currently defined by Marine Aviation Weapons and Tactics Squadron One (MAWTS-1) as 0.0022 lux. Lux is a measurement of illuminance, or light generated from a source. The moon, in the case of NVG operations, is considered a source of light. A 20% moon disk positioned 30° above the horizon equates to 0.0022 lux. On an overcast, moonless night the sky still provides 0.0001 lux of illumination. Lux levels can be obtained from the SLAP program. While the light levels provided by SLAP are based purely off moon phase and position, the moon is not your only source of light. As covered, light levels will be increased with the addition of starlight or cultural lighting.

NVG brightness remains constant from full moon down to approximately quarter moon illumination through activation of the NVGs’ ABC. As light level decreases below quarter moon, NVG image brightness will decrease until the ABC is at maximum gain.

When a bright light source enters the NVG FOV, BSP will be activated to reduce gain, therefore making it difficult to see anything but the light source. Visibility is further degraded by the “blooming effect” around the light source. Blooming occurs because electrons from the photocathode “bleed over” into neighboring channels of the MCP and appear as coming outside of the halo circle. These effects become much more significant in LLL conditions. One should take this into consideration when conducting mission planning.

THIS PAGE INTENTIONALLY LEFT BLANK

CHAPTER FIVE
NVG AEROMEDICAL FACTORS

500. SCOPE

This chapter provides a basic understanding of how the human body performs in the night environment.

501. VISUAL ACUITY

During daylight, visual acuity, or sharpness, is 20/20. A value of 20/80 indicates that an individual reads at 20 feet the letters that an individual with normal acuity (20/20) reads at 80 feet away. In the night environment, visual acuity is typically considered to be 20/200 depending on the level of illumination. Because of the decreased level of acuity in the night environment, FAA regulations increase the statute mile visibility requirements for VFR flight at night compared to day.

During day VFR flight, pilots process their attitude relative to the horizon at an almost automatic and subconscious level since the horizon can be seen in their peripheral vision. During unaided night flight, the horizon in not clearly visible in our peripheral so pilots must focus more attention on scanning the attitude instruments. This increased work load reduces the amount of attention pilots can give to other flight related tasks. The lack of peripheral reference and reduced visual acuity also affects the pilot’s ability to process ground speed, height above the ground, and distance.

The human visual system is functionally divided into two distinct systems, the **central** and **peripheral** systems as seen in the following table.

Central Vision	Peripheral Vision
Information: What is there?	Information: Where am I?
Conscious Control	Subconscious Control
Small Field of View (2°)	Large Field of View (180°H X 140°V)
Excellent Visual Acuity (20/20)	Poor Visual Acuity (<<20/20)
Color Vision	Shades of gray

Figure 5-1 Human Visual System

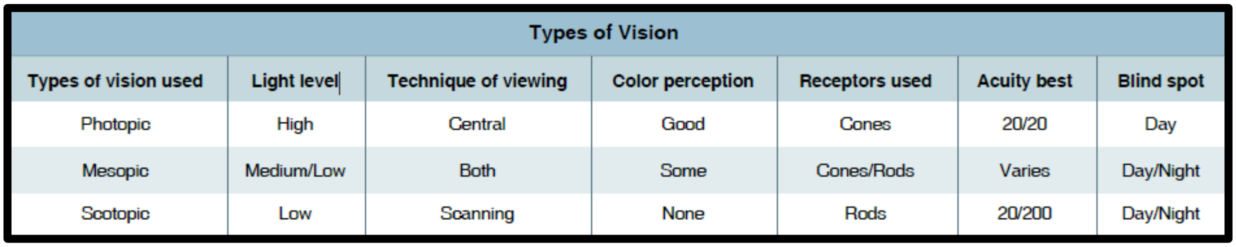
Maintaining spatial orientation requires input from both components of the visual system, central (focal) vision, and peripheral (ambient) vision. Central vision is primarily a conscious function that largely supports object recognition tasks. Peripheral vision is primarily a subconscious function that uses multiple inputs to form one’s spatial orientation.

502. VISION TYPES

1. **Photopic vision** provides the capability for the eye to see color and resolve fine detail (20/20 or better), but it functions only in good illumination. Photopic vision is predominately used during daylight or when a high level of artificial illumination exists. The cones concentrated in the fovea of the eye are primarily responsible for vision during well-lit conditions.

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

3. **Scotopic vision** is experienced under low-light levels and the cones become ineffective, resulting in poor resolution of detail as visual acuity decreases to 20/200 or less. In other words, a person must stand at 20 feet to see what can normally be seen at 200 feet under daylight conditions. When using scotopic vision, color perception is lost and a night blind spot in the central field of view appears at low light levels when cone-cell sensitivity is lost. Aviators never use true scotopic vision since light sources inside the cockpit and cultural light sources outside the aircraft keep them in mesopic vision to some degree.



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

Figure 5-2 Types of Vision

503. DARK ADAPTATION

Dark adaptation is the process by which the eyes increase their sensitivity to low levels of illumination. Going suddenly from bright light into darkness is something people experience every day. When people enter a dark room they see very little, if anything. After several minutes, they can see dim forms and large outlines. As time goes by, more details of the environment become apparent as further dark adaptation occurs.

Individuals dark-adapt to varying degrees and at different rates. During the first 30 minutes, the sensitivity of the eye increases exponentially as rhodopsin build up in the rods. A negligible increase in sensitivity occurs after that time. When fully sensitized (dark-adapted), the rod cells may become up to 10,000 times more sensitive than at the start of the dark adaptation period. When the eye is fully adapt to the dark, rods are the sensing cells that provide vision.

The lower the starting level of illumination, the more rapidly complete dark adaptation occurs. Less time is required to dark-adapt completely after leaving a dark red briefing room then after leaving a bright-lit hangar.

Because rods are very sensitive to light, any exposure to it will impair night vision. If the dark-adapted eye is expose to a bright light, the amount of impairment depends on the intensity and duration of the exposure. Brief flashes from a white strobe anti-collision light, have little effect on night vision because the pulse of energy are of short durations (milliseconds). On the other hand, exposure to a flare or steady artificial light longer than one second can seriously impair night vision. Depending on the brightness, duration of exposure, or repeated exposures, the time to regain complete dark adaptation could take from several minutes up to 45 minutes or longer.
Photopic (Cone) and scotopic (rod) sensitivity is affected by the light wavelength. Rods absorb less and are less affected by the wavelength of a dim red light. Therefore, dim red lights are the preferable light color during unaided operations. Consideration should be given to the color of pens and markers used when marking maps as some colors will be invisible or much harder to see when using a red light in the aircraft.

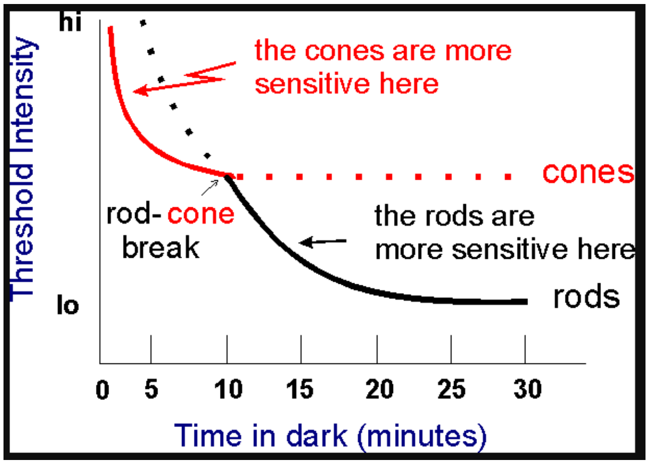


Figure 5-3 Rod and Cone Sensitivity

504. NIGHT BLIND SPOT

It is estimated that once fully adapted to darkness, the rods are 10,000 times more sensitive to light than the cones, making them the primary receptors for night vision. Since the cones are concentrated near the fovea, the rods are responsible for much of the peripheral vision. The concentration of cones in the fovea can make a night blind spot in the center of the field of vision. The night blind spot involves an area from 5 to 10 degrees wide in the center of visual field. If any object is viewed directly at night, it may not be seen because of the night blind spot unless it is artificially illuminated.

It is important to understand that the night blind spot area increases with distance. Even large objects cannot be detected if they are far enough away and fall within the night blind spot.

To see an object clearly at night, the pilot must expose the rods to the image. This can be done by looking 5° to 10° off center of the object to be seen. When looking directly at the light, it dims or disappears altogether. When looking slightly off center, it becomes clearer and brighter.

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

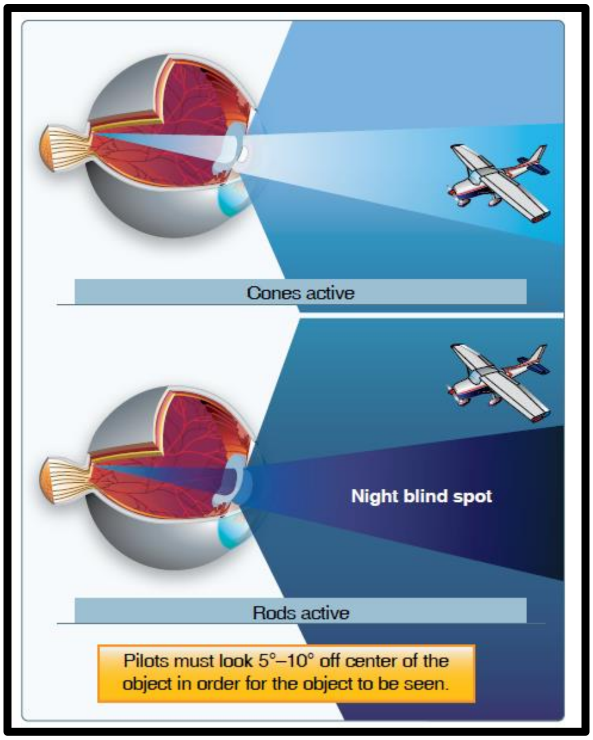


Figure 5-4 Central and Peripheral Vision

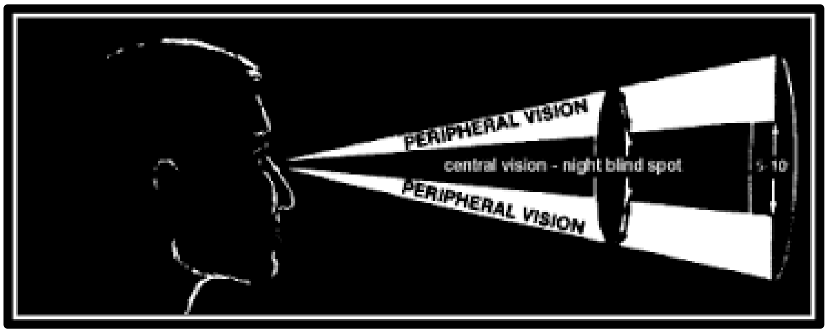


Figure 5-5 Night Blind Spot

505. PERIPHERAL VISION

Peripheral vision occurs with the stimulation of only rod cells. Pilots use peripheral vision to overcome the limitations of scotopic vision. Peripheral vision enables pilots to see dimly lit objects and maintain visual reference to moving objects. The natural reflex of looking directly at an object must be reoriented through night-vision training and night scanning techniques. To compensate for scotopic vision, pilots must use scanning techniques to locate an object and small eye movements to retain sight of the object. If the eyes are held stationary when focusing on abject from more than two or three seconds using scotopic vision, an image may fade away completely.

Off-center viewing can be used for night scanning. Unlike day scanning, however, this scanning technique focuses objects on the rods rather than the fovea/night blind spot. When looking at an object, avoid staring at it too long. Staring at an object without moving the eyes, causes the retina to become accustomed to the light intensity and the image begins to fade. This occurs because the rods reach a photochemical equilibrium that prevents any further response until the scene changes. To keep the object clearly visible, new areas in the retina must be exposed to the image. Small, circular eye movements help eliminate the fading. Also, move the eyes more slowly from sector to sector than during the day to prevent blurring.

The technique of off center vision applies only to the surveillance of targets that are minimal illuminated. Under these conditions, cone vision is not stimulated. Central vision is best used when an object or target is bright enough to stimulate the cones and needs to be seen with considerable detail. When the object or target begins to fade, it should be redetected using off-center vision and retained until central vision recovers sufficiently to permit further observation.

Observer

Once a target is detected in the peripheral field of dark-adapted vision, aircrews maintain continual surveillance by using the off-center vision technique. They look 10 degrees above, below, or to either side of the target, viewing it no longer than two to three seconds at each position.

Figure 5-6 Off-center Vision Technique

506. OBSTRUCTION DETECTION

The ease with which an object can be seen depends on various factors. Each factor can either increase or decrease the visibility of an object. The visibility of an objective **increases** as the:

1. Distance between the object and the viewer decrease. Angular size is the angle between the lines of sight to its two opposite sides.

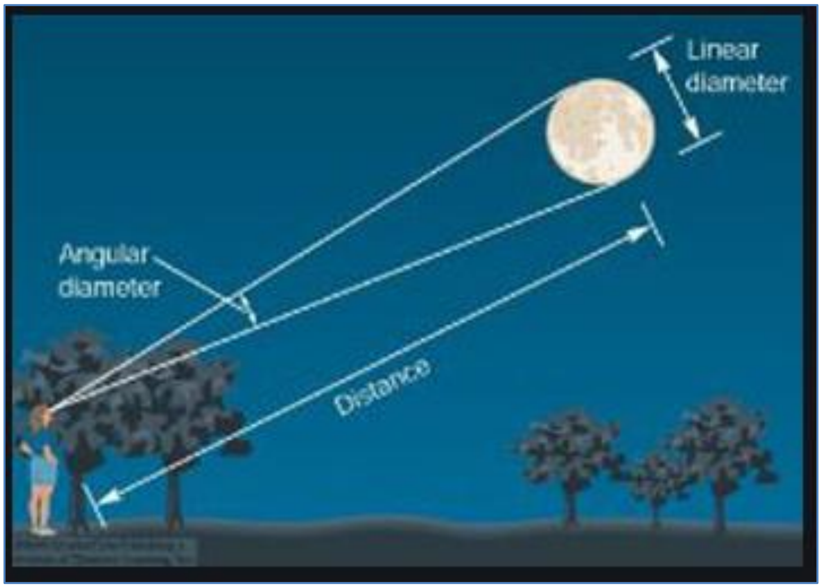


Figure 5-7 Angular Size Difference

2. For example, the angular size of the horizon is about 180 degrees. An object's angular size is a measure of how large the object actually appears to be. This is a function of both the actual size of the object and its distance away.

3. Illumination of ambient light ***increases***.

4. Degree of retinal adaptation ***increases*** – More rods adapted to night vision.

5. Color and contrast between the target and background ***increases***.

6. Position of the target within the visual field (visibility threshold) ***increases.***

7. The focus of the eye and length of time viewing the object ***increases.***

8. Atmospheric clarity ***increases.***

As speed increases, there is interference in the perception of instantaneous visual picture, which increases the time to recognize, and consciously assess a complex situation. The time that it takes to perceive an object become significant to pilots flying at night. Proper scanning can decrease perception time and the time it takes for:

- The eye to turn toward and focus on the unknown object.
- The pilot to recognize the object and determine its importance.
- The brain to transmit a decision to move muscles and cause the aircraft to respond to control inputs.

507. HUMAN FACTORS

Night flight can be more fatiguing and stressful than day flight, and many self-imposed stressors can limit night vision. Some of these factors are listed below and pilots can remember these factors by using the acronym DEATH.

1. **Drugs**

Some over the counter and prescription drugs can seriously degrade visual acuity during the day and especially at night.

2. **Exhaustion**

Pilots who become fatigued during a night flight will not be mentally alert and will respond more slowly to situations requiring immediate action and will struggle to multi-task or handle routine procedures. Their performance may become a safety hazard depending on the degree of fatigue.

Poor Physical Condition. Pilots who are physically fit become fatigued during flight but are more resilient. However, too much exercise may have a detrimental effect.

3. **Alcohol**

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

4. **Tobacco**

Cigarette smoking significantly decreases visual sensitivity at night. It increases the amount of carbon monoxide carried by the hemoglobin in red blood cells which reduces the blood’s capacity to carry oxygen throughout the body. This lack of oxygen (hypoxia) caused by carbon monoxide poisoning affects peripheral vision and dark adaptation. The results are the same as those for hypoxia caused by high altitude. Smoking 3 cigarettes in rapid succession or 20 to 30 cigarettes within a 24-hour period may saturate from 8 to 10 percent of the capacity of hemoglobin. Regular smokers lose 20 percent of their night vision capability at sea level, which is equal to a physiological altitude of 5,000 feet.

5. Hypoglycemia and Nutritional Deficiency

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

508. FATIGUE

Fatigue is 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. Boring or monotonous tasks may increase fatigue. As either many other physiological problems, crewmembers may not be aware of fatigue until they make serious errors. Sleep deprivation, disrupted diurnal cycles, or life-event stress may all produce fatigue and concurrent performance decrements.

Fatigue is frequently associated with pilot error. Some of the effects of fatigue include degradation of attention and concentration, impaired coordination, and decreased ability to communicate. These factors seriously influence the ability to make effective decisions. All flight crews experience some type of fatigue. However each individual will react and cope with fatigue differently, based on their level of physical and psychological fitness, rest levels, and overall experience in dealing with various in-flight circumstances.

Total prevention of fatigue is impossible, but its effects can be moderated by:

1. Controlling the sleep environment by keeping it dark, quite, and cool

2. Maintaining good health and physical fitness

3. Practicing good eating habits by maintaining a balanced diet

4. Practicing moderate controlled use of alcohol and caffeine

5. Avoiding self-impose stress

6. Taking naps

7. Adjusting to night shift work by:

    a. Maintaining an consistent sleep-wake schedule

    b. Avoiding exposure to daylight

c. Eating a light snack before going to sleep

d. Avoiding caffeine consumption for six hours before going to sleep

509. TYPES OF FATIGUE

Fatigue falls into three broad categories: acute, chronic, and motivational exhaustion, or burnout.

1. Acute Fatigue

Acute fatigue is short-term and a normal occurrence in everyday living. It is associated with physical or mental activities between two regular sleep periods. The loss of both coordination and awareness of errors is the first type of fatigue to develop. Acute fatigue is the kind of tiredness people feel after a period of strenuous effort, excitement, or lack of sleep.

a. Acute fatigue has many causes, but the following are among the most important for the pilot:

    i. Mild hypoxia (oxygen deficiency)

    ii. Physical stress

    iii. Psychological stress

    iv. Depletion of physical energy resulting from psychological stress

    v. Sustained psychological stress

b. Acute fatigue is characterized by:

    i. Inattention

    ii. Distractibility

    iii. Errors in timing

    iv. Neglect of secondary tasks

    v. Loss of accuracy and control

    vi. Lack of awareness of error accumulation

c. A particular type of acute fatigue is skill fatigue. It has two main effects on performance:

   i. Timing disruption—appearing to perform a task as usual, but the timing of each component is slightly off. This makes the pattern of the operation less smooth because the pilot performs each component as though it were separate, instead of part of an integrated activity.

   ii. Disruption of the perceptual field—concentrating attention upon movements or objects in the center of vision and neglecting those in the periphery. This is accompanied by loss of accuracy and smoothness in control movements.

2. Chronic Fatigue

Chronic fatigue, extending over a long period, usually has psychological roots, although an underlying disease is sometimes responsible. Continuous high-stress levels produce chronic fatigue. Chronic fatigue is not relieved by proper diet and adequate rest and sleep and usually requires treatment by a physician. An individual may experience this condition in the form of weakness, tiredness, and palpitations of the heart, breathlessness, headaches, or irritability. Sometimes chronic fatigue even creates stomach or intestinal problems and generalized aches and pains throughout the body. When the condition becomes serious enough, it leads to emotional illness. Pilots who suspect they are suffering from chronic fatigue should consult a physician.

3. Burnout

If chronic fatigue persists for too long, the individual will eventually “shut down” and cease functioning occupationally and socially.

510. CIRCADIAN RHYTHM

Circadian rhythms are physical, mental, and behavioral changes that follow a 24-hour cycle. These natural processes respond primarily to light and dark and affect most living things. Circadian Rhythms regulates the sleep-wake cycle and repeats on each rotation of the Earth roughly every 24 hours. Alteration of the body biological circadian rhythms generates high fatigue levels and low performance.

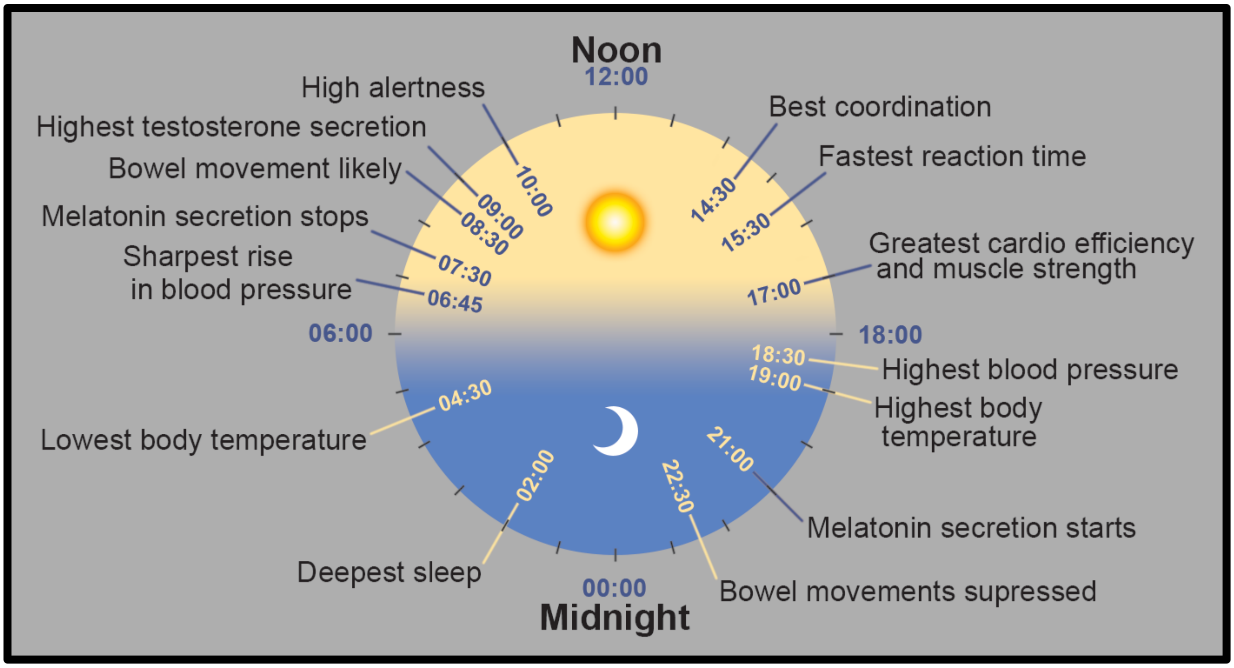


Figure 5-8 Typical Circadian Cycle

511. VISUAL ILLUSIONS

Piloting is inherently visual (both central and peripheral), and the visual system is deeply intrinsic to orientation. On the ground, the visual world is Earth-stable. In flight (a dynamic force environment), there are significant changes in the interaction between the visual world and the force environment. Visual illusions give false impressions or misconceptions of actual conditions; therefore, crewmembers must understand the types of illusions that can occur and the resultant potential for disorientation.

Some illusions can result from misinterpreting what is seen; what is perceived is not always accurate. Even with references outside the cockpit and instrument displays inside (integrated scan), crewmembers must be vigilant to interpret information correctly.

1. **Vection (Induced Motion Illusion)**

Induced motion is falsely perceived motion of oneself when no physical motion is occurring. The most common example is vection—visually induced perception of self-motion. Consider the example of an individual in a car stopped at a traffic light and another car slowly pulls alongside. The individual stopped at the light may perceive the other car’s forward motion as his or her own rearward motion, resulting in the individual suddenly applying additional pressure to the brakes. Another common example is that of two adjacent trains whereby a passenger on one misperceives self-motion due to the movement of the other train. This illusion can be encountered during flight in situations such as formation flight, hover taxi, or hovering over moving water, blowing snow or dust, or movement of tall grass.

2. False Horizon Illusion

False horizon illusions occur when a pilot confuses a wide sloping plane of reference such as sloping cloud tops, mountain ridges, or so-called ‘cultural’ lighting at night (such as a coastline or highway) with the true horizontal (Figure 5-9). A sloping cloud deck, for example, can be difficult to perceive as anything but horizontal if it extends any great distance in the pilot’s peripheral vision. The pilot might perceive the cloud bank to be horizontal even if it is not horizontal to the ground and position the aircraft into a banked attitude thinking it is level. This condition is often insidious and may go undetected until the pilot recognizes it via cueing to instruments and makes necessary corrections. This illusion may also occur if the pilot looks outside after having given prolonged attention to a task inside the cockpit. Confusion can result in the pilot incorrectly placing the aircraft “level” according to the sloping cloudbank.

Figure 5-9 False Horizon Illusion

3. Confusion with Ground Lights

A related illusion, confusion with ground lights, occurs when a pilot mistakes ground lights for stars. The illusion prompts the pilot to place the aircraft in an unusual attitude to keep the misperceived ground lights above the aircraft. Isolated ground lights can appear as stars, which could lead to the illusion the aircraft is in a nose-high or one-wing-low attitude (Figure 5-10, part A). When no stars are visible because of overcast conditions, unlighted terrain can blend with the dark overcast to create the illusion the unlighted terrain is part of the sky (Figure 5-10, part B). This illusion can be avoided by referencing the flight instruments and establishing true horizon and attitude.

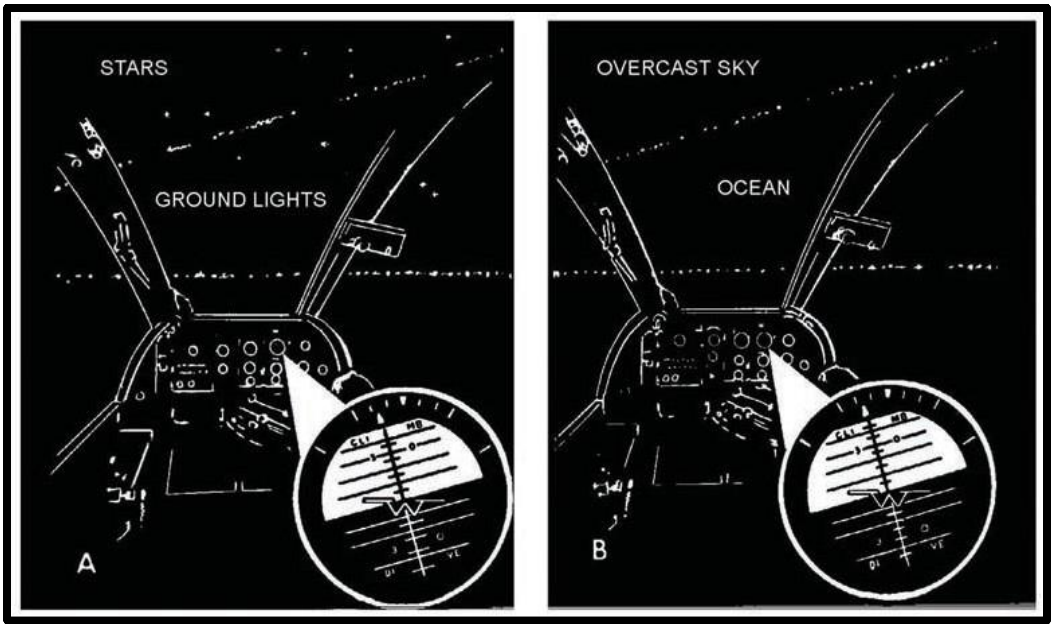


Figure 5-10 Confusion with Ground Lights and Stars

4. Height-Depth Perception Illusion

Height-depth perception illusions are due to absent or insufficient visual cues and cause crewmembers to misjudge depth perception. Flying over areas devoid of visual references such as desert terrain, snow, or water may deprive crewmembers of their perception of height. Misjudging the aircraft's true altitude, the pilot might fly the aircraft dangerously low to the ground or other obstacles above the ground. Flight in an area where visibility is restricted by misty rain, fog, smoke, whiteout, brownout, or haze can produce the same illusion.

5. Crater Illusion

Crater illusions occur when crewmembers land at night under NVGs and the infrared searchlight is directed too far under the aircraft's nose. This combination creates the illusion of landing with up sloping terrain in all directions or landing in a crater. This illusionary depression lulls the pilot into continually lowering the collective and could result in the aircraft prematurely impacting the ground. If observing another aircraft during hover taxi, the pilot might perceive the crater is moving with the aircraft being observed.

6. Structural Illusion

Structural illusions are caused by the effects of rain, snow, sleet, heat waves, or other visual obscurants. A straight line can appear curved when viewed through heat waves in the desert. A single position light might appear as a double light or in a different location when viewed through rain. Curvature of the aircraft windscreen also can cause structural illusions due to the refraction of light rays as they pass through the windscreen. Pilots must remain vigilant to the potential for false perceptions when operating in environments containing these obscurants.

7. Size-Distance Illusion

Size and shape constancy are important when a familiar object's known size and shape is used to judge its distance from the observer. Size-distance misperceptions give rise to several related illusions whereby a crewmember misinterprets an object of unfamiliar size and shape by comparing it with what they are accustomed or familiar to seeing based on experience.

8. Size Constancy

A common example of a size constancy illusion is that of landing at an unfamiliar runway (Figure 5-11). A runway that is narrower than expected may cause the pilot to think he or she is higher and further away resulting in the flying of the approach too low and landing short; likewise, a wider runway than expected may cause the pilot erroneously to think he or she is closer resulting in flying the approach too high and landing long.

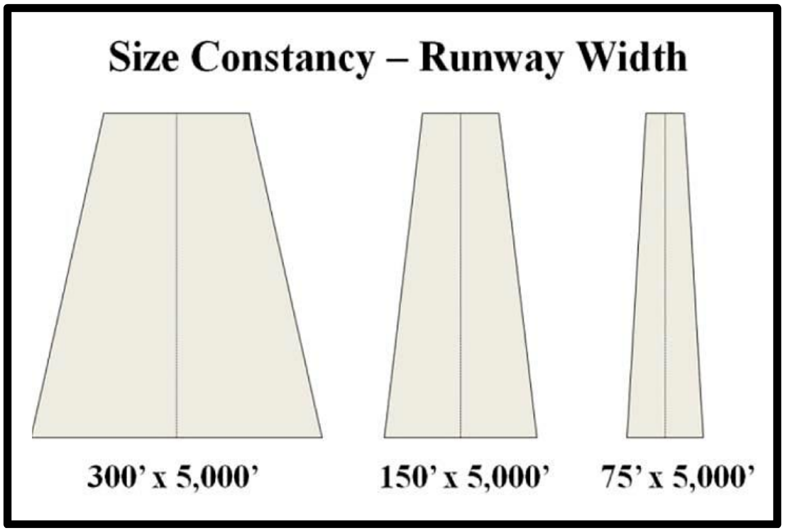


Figure 5-11 Size Constancy

9. Shape Constancy

A related illusion is that of shape constancy, which is commonly encountered with sloping runways. A typical glideslope to landing of 3 to 4 degrees is such that only a one degree change in runway slope can affect the landing sight picture. With the shape constancy illusion, the foreshortened picture of an up-sloping runway may give the pilot the illusion of being too high. A natural tendency is for the pilot to want to 'reshape' the sight picture resulting in flying the approach too low. The reverse is true for a down-sloping runway. In both cases, being forewarned of the potential hazard with good pre-mission planning and cross-checking the instruments during the approach are important.

10. Aerial Perspective

Another size-distance illusion is that of aerial perspective. These illusions can occur if visual cues are of a different size, clarity, and/or discrimination than expected. A classic example would be for a pilot to mistake immature, short, or stunted trees for large, tall ones causing him or her to misjudge altitude above the ground. A different but somewhat related phenomenon may occur in rain, smoke or haze, whereby a pilot may erroneously think that the lights of another aircraft or runway approach lighting to be much farther away than actual distance due to lack of brightness and clarity. Objects viewed within a hazy environment, for example, are often thought to be further away.

11. Fascination (Fixation) in Flying

While not a visual illusion, per se, this can be just as deadly. Fascination or fixation in flying can be separated into two categories: task saturation and target fixation. Task saturation occurs when crewmembers become so engrossed with a problem or task within the cockpit that they fail to properly scan outside the aircraft. Target fixation, commonly referred to as target hypnosis, occurs when crewmembers ignore orientation cues, and focus their attention on an object or goal. For example, a skid pilot on a gunnery range might become so intent on hitting a target that he or she forgets to fly the aircraft, causing it to strike the ground, target, or shrapnel.

12. Autokinesis

Autokinesis occurs primarily 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, an individual may perceive movement at up to 20 degrees in any direction or in several directions in succession, although there is no actual object displacement. This illusion can cause a pilot to mistake the fixated object for an object in motion (such as another aircraft). In addition, a pilot flying at night might perceive a relatively stable lead aircraft to be moving erratically when, in fact, it is not. The unnecessary and undesirable control inputs the pilot makes to compensate for the illusory movement result in increased workload and wasted motion at best and an operational hazard at worst.

THIS PAGE INTENTIONALLY LEFT BLANK

CHAPTER SIX
NVG BRIEFING AND SAFETY CONSIDERATIONS

600. SCOPE

This chapter is intended to highlight the differences from daytime that should be included in an NVG navigation route brief.

601. MISSION BRIEFING PROCEDURES

The format of the NVG mission brief will follow the same OSMEAC format used in the low-level navigation events. Like the Formation syllabus, the NVG syllabus will be more extensive in the topics covered in the brief. The student will utilize the standard briefing card found in ***Appendix B***. The additions and changes to the navigation brief that should be considered and covered are outlined below.

1. **Orientation:** All SLAP data information will be briefed with the weather brief. Consideration should be given to brief the effects the weather will have on NVG performance during the flight.

2. **Situation:** No change.

3. **Mission:** No change.

4. **Execution:** It is paramount that the crew adds NVG scene interpretation information to their mission brief. A particular route brief for a daytime mission should contain different information and descriptions of features from that of the same route while NVG-aided.

For route checkpoints, utilize the "N" in FALCON to cover NVG considerations for each checkpoint and leg of the route.

When briefing the Landing Zone (LZ), use an LZ Diagram and cover applicable information specific to NVG operations. ***See 1-8 of Low-Level Navigation FTI.***

Possible NVG considerations include:

- a. Effects of moon position on course and checkpoints
- b. Describe cultural lighting and its harmful or beneficial effects
- c. Any impact shadows have on navigation or safety of flight
- d. Terrain contrast/albedo along route legs or at checkpoints
- e. Effects of weather on NVG performance
- f. Effects of dust, snow, sand, or other obscurants on landing profile

5. **Coordinating Instructions:** When briefing the IIMC plan list cues to reductions in ambient illumination that indicate the presence of instrument meteorological conditions when using NVGs.

6. **Common Errors**

a. Failure to mention NVG considerations, including SLAP data, terrain contrast, cultural lighting effects, visibility of airfield lighting/beacons etc.

b. Failure to brief operations at the LZ or OLF, along with appropriate NVG considerations.

c. Failure to follow chart preparation instructions.

d. Lack of preparation and failure to rehearse the brief or conduct a proper map study.

e. Failure to properly set up the briefing space or "preflight" briefing equipment.

f. Lack of eye contact with the audience or excessive movement in front of the audience.

g. Setting up an incorrect timeline for the flight, two identical take-off times, or incorrect take-off times.

h. No mention of radio frequency or squawk changes along route.

i. Incorrect Bingo calculations or calculated to a closed fuel source or calculated incorrectly.

602. AIRCRAFT EMERGENCIES

It is recommended that the PAC remain goggled and initiate required immediate action procedures. Terrain permitting, primary consideration should be given to landing the aircraft followed by the execution of remaining procedures on the deck. Where terrain prohibits this course of action and emergency procedures permit, it is advisable to "climb to cope" to gain reaction time, improve landing site selection, and increase overall SA. The PNAC should remain goggled to retain outside visual cues while simultaneously assisting the pilot at the controls as briefed or required.

During NVG flight, one's ability to effectively respond to an emergency may be delayed due to the reduced visual cues and accompanying physiological and psychological stressors. To overcome these limitations, the aircrew must be proficient in handling aircraft emergencies and systems failures in a darkened cockpit environment. When briefing, safety considerations may be divided into aircraft emergencies, NVG failures, inadvertent IMC, loss of SA, and aircrew coordination. In all cases, appropriate procedures should be tailored for the mission, ambient conditions, weather factors, terrain, and aircrew experience. Conducting a blindfold cockpit check prior to aided flight can greatly increase cockpit familiarization and, thus, decrease response time in an emergency.

603. INADVERTENT INSTRUMENT METEOROLOGICAL CONDITIONS (IIMC)

The chances of entering inadvertent IMC are increased due to the goggle's ability to see through some atmospheric obscurants as well as its inability to detect others until it's too late. Night unaided and NVG IIMC considerations are the same. However while flying NVGs the aircrew must be alert and recognize the following indicators to IMC:

1. Increased "halo effect" around light sources. The halo size will increase as weather restrictions develop.

2. Degraded NVG image. Gradual reduction in light levels, visual acuity, depth perception, or terrain contrast.

3. Obscuration of the moon and stars. The less visible they are, the heavier the cloud cover. Additionally, shadows obscuring the moon's illumination are an indication that clouds are present. Shadows may be detected by observing the varying levels of ambient light along the route.

4. Increased graininess or video noise. Video noise is similar to "snow" seen on televisions with poor reception. Should this occur, verify the condition with other crewmembers to distinguish weather restrictions from NVG malfunctions.

5. Loss of ground lights.

6. Reflection of exterior aircraft lights off moisture in the air.

604. NVG FAILURES

NVGs are susceptible to malfunction. Battery failure, broken intensifier tubes, broken frames, or broken wires may occur. The majority of NVG failures should be caught during proper preflight of the helmet and NVGs. As with all emergencies, the priority when handling NVG malfunctions should be to aviate, navigate, and communicate in that order. The following steps shall be taken for NVG malfunctions:

1. For any phase of flight during a NVG malfunction the PAC shall first immediately shift to an instrument scan, execute the appropriate maneuver, communicate the failure to the crew, and finally conduct a positive three-way transfer of controls to the PNAC when it is safe to do so.

2. If the PAC has a goggle failure at altitude, they shall establish an instrument scan and simultaneously announce, *"I have a goggle failure."* A three-way positive transfer of controls to the PNAC shall occur when it is safe to do so.

3. If the PAC has a goggle failure on takeoff, they shall establish an instrument scan, execute an ITO profile, and simultaneously announce, *"I have a goggle failure, executing an ITO."* A three-way positive transfer of controls to the PNAC shall occur when it is safe to do so.

4. If the PAC has a goggle failure on final, they shall establish an instrument scan, execute a wave-off, and simultaneously announce, *"I have a goggle failure, executing a wave-off."* After the wave-off has been initiated a three-way positive transfer of controls to the PNAC shall occur when it is safe to do so.

NOTE

When executing the wave-off, transfer immediately to an instrument scan, add power to at least HIGE torque to initiate a climb, center the ball, and ensure nose attitude is approximately on the horizon. Check VSI for a positive rate of climb, then ensure airspeed is accelerating towards 70 KIAS.

NOTE

There are situations where a wave-off will not be possible after an NVD failure (i.e., during a confined area landing after transitioning below the tree line). During these situations, the PNAC shall be immediately ready to take control to affect the landing. Proper CRM and individual roles and responsibilities shall be briefed if such approaches are to be flown.

5. Once the aircraft is in a safe condition, attempt to troubleshoot the malfunction as follows:

   a. Check for a battery failure by switching to the backup battery or replace with spare batteries.

   b. Check the NVG mount and wiring harness for good connectivity.

   c. If NVGs are still not operational, replace them with spare NVGs.

6. If the NVG malfunction cannot be corrected, the training event shall terminate, and the crew should return to base. The remaining set of operational NVGs may continue to be used at the aircraft commander's discretion to maximize crew situational awareness.

NOTE

A minimum of one extra set of goggles should be carried on the aircraft as a replacement set for any that become inoperable. Sufficient extra batteries should also be carried by each individual crewmember.

NOTE

Extra batteries may be found in the Clip on Power Supply or the Sidewinder Flashlight. Due to TH-57 limitations and mission precedence, extra sets of NVGs may not be available.

− **Common Errors**

- Failure to immediately establish an instrument scan upon NVG failure.
- Releasing controls before a three-way positive transfer of controls has occurred.
- Passing and/or releasing controls upon NVG failure before ensuring aircraft is in a safe regime of flight.
- Failure to properly scan instruments and establish a positive rate of climb and increasing airspeed during an NVG failure on final approach.

THIS PAGE INTENTIONALLY LEFT BLANK

CHAPTER SEVEN
NVG INTEGRATED SCAN

700. SCOPE

The lack of peripheral cues, reduced visual acuity, monochromatic image, and the greatly reduced field of view (FOV) all present challenges to flying a helicopter while aided by NVGs. The fundamentals of flight do not change, but it is incumbent upon the aviator to adjust their scan to obtain the requisite information necessary to maintain flight parameters. Limited visual information requires a reliance on an instrument scan at some level in nearly all regimes of flight. The limited visual references available will necessitate use of the NVG Integrated Scan.

The NVG Integrated Scan is a fluid transition between the principles of a VFR outside scan through the NVGs and those of basic instrument flight. Reliance on instruments or outside cues must be tailored to the maneuver being performed.

This chapter is intended to address specific techniques and considerations for operating while aided with NVGs.

701. ATTITUDE FLIGHT

All helicopter flight is with reference to attitude. Depending on the flight profile and environmental conditions, the source of attitude information will change. In VMC the primary attitude reference is the horizon. In IMC, the primary attitude reference is the attitude indicator. Regardless of which source is used to obtain attitude information, the pilot must adjust attitude to obtain the desired movement over the ground. In NVG-aided flight, the pilot must blend the VMC and IMC scan references to build a complete picture.

During daytime VFR flight, the wide field of view (FOV) of the human eye (190º horizontal x 140º vertical) detects the horizon and optical flow using peripheral cues automatically and processes much of the information subconsciously. In NVG-aided flight, the pilot must try to provide their brain with the same amount of visual information as during daytime flight. The narrow 40º FOV of NVGs reduces or eliminates the ability to use peripheral cues. To overcome this FOV limitation, the pilot must actively scan throughout the entire field of regard (FOR) to help build an understanding of how the aircraft is moving through the environment.

Figure 7-1 shows the relationship between the NVG FOV vs. the NVG FOR. The FOR describes the area that the sensor (in this case the NVG) can view through its maximum range of motion. The FOV describes the specific area that the sensor can view at any given moment in time. The goal of the outside NVG scan should be to provide as much visual information within the field of regard as is necessary to maintain acceptable flight parameters. This can be thought of as an attempt to capture the same relevant references one would observe throughout the normal daylight 190º x 140º field of view. These references in a hover include the horizon, drift/altitude cues, and obstacles. In forward flight, these include the horizon, traffic, ground track cues, obstacles, and objects to either side of the aircraft.

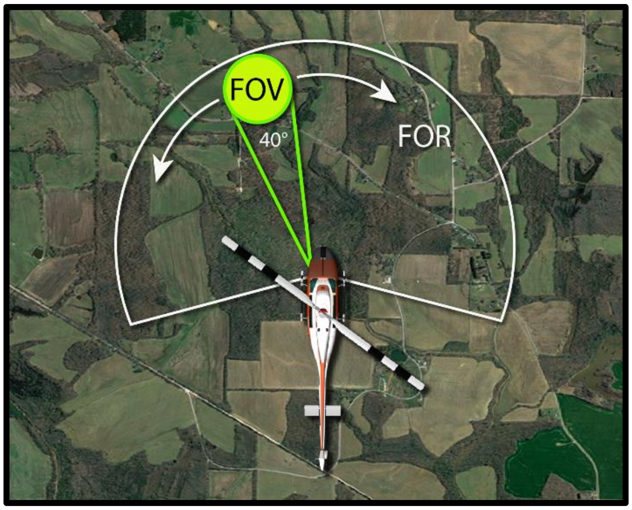


Figure 7-1 NVG Field of View (FOV) vs. NVG Field of Regard (FOR)

Actively scan for these cues by moving the NVG scan to targeted areas to collect the appropriate visual data, while remembering that this visual data is subject to a decrease in acuity dependent on ambient lighting conditions. In addition, the pilot must supplement the visual scan by incorporating appropriate flight instruments to validate perceptions of motion. The pilot must constantly monitor attitude, altitude, airspeed, obstacles, track, navigation information, and engine/transmission instruments while combining both an aided and unaided outside scan.

Every aircraft will have different limitations based on cockpit design. Each pilot will develop a unique technique. The discussion in this section will focus on techniques specific to the TH-57. While techniques for other aircraft will differ based on cockpit limitations, ultimately the concept remains the same.

702. BREAKDOWN IN SCAN

Several items can cause a breakdown in scan. Among them are inattention, unawareness, and fixation. Inattention is commonly caused by fatigue, as discussed in Chapter 5. Unawareness is the result of inexperience or poor training and is characterized by not considering all the factors that must be included in the scan. Fixation occurs when a pilot focuses all their attention on one item.

Fixation is a common cause of NVG mishaps and near misses. The pilot can become fixated on any number of items inside or outside the aircraft and lose SA on other important elements. Fixation is typically caused by an item that the pilot perceives to be either a critical threat, that requires immediate and undivided attention or by an item that the pilot determines to provide so much useful information that they ignore other cues. A common example is when all crew members become fixated on troubleshooting a system malfunction. At this point no one is flying the aircraft. Target fixation is another common cause. Aircrew conducting ordnance delivery can become so focused on lining up the target in their sights, that they lose SA of altitude and closure rate cues and crash into the target. Similarly, a pilot attempting to hover may lose SA of forward or aft drift if they focus their attention forward of the aircraft to control lateral drift.

703. SCAN AT ALTITUDE

When flying at altitude, the reduced FOV, reduced visual acuity, monochromatic image, and halos all contribute to illusions and misperceptions. In most cases it is better to think of "illusions and misperceptions" as lack of perception. Pilots using NVGs often struggle to recognize altitude and airspeed deviations. Incorporating an aggressive basic instrument cross check will aid the pilot in detecting deviations and correcting appropriately. In addition, the pilot must integrate an unaided scan to detect obstacles that may be difficult to identify through the NVGs. To fly safely and effectively on NVGs, the pilot must constantly scan flight instruments to validate the flight profile as well as the outside environment; both through the NVGs and around the NVGs for navigation features and hazards.

704. HOVER SCAN

Regardless of day or night, to control the aircraft the pilot must be able to determine altitude, drift over the ground, and attitude in reference to the horizon. During daytime, much of this information is sensed through peripheral vision. The brain often interprets these cues on a subconscious level and automatically notifies the pilot that the aircraft is drifting. The pilot then determines the appropriate attitude change to correct the drift and makes the control input.

While NVG-aided in a dark environment with no artificial lighting, there is a complete lack of peripheral cues, a reduced FOV and reduced visual acuity. The pilot must now make a conscious effort to scan for multiple references both in front and to the side of the aircraft to detect fore/aft and lateral drift that are usually handled at the subconscious level in the daytime.

In the TH-57, many pilots prefer to look at approximately a 45° bearing from the aircraft to detect references to the side of the aircraft. The 45° bearing can be described as the area between the instrument panel and the doorframe on each side of the cockpit.

When building a hover scan, the pilot must choose useful visual reference points. Look for objects that provide good contrast between different albedos, such as the interface between pavement and grass, distinct shapes, or light sources. The closer the reference is to the aircraft, the more useful it will be for controlling drift; however, a close-in reference point will not be as useful for altitude or heading cues, necessitating a periodic scan toward the horizon. If the scan is fixated too close to the aircraft without incorporating other references within the field of regard further from the aircraft, the pilot will not have reference to the horizon. This will lead to over-controlling the helicopter and cause deviations.

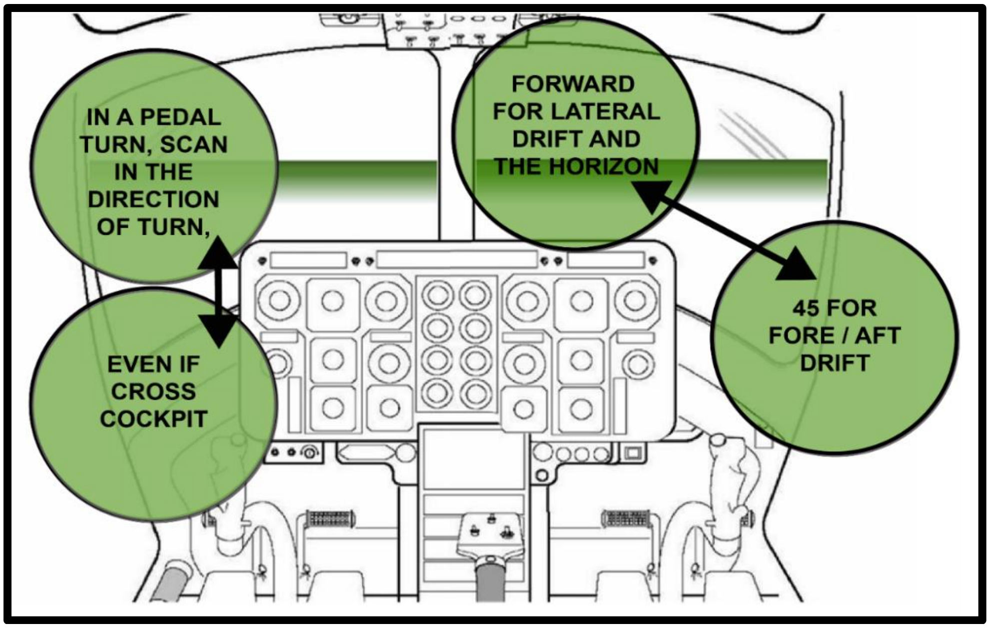


Figure 7-2 NVG Hover Scan Locations

705. INCORPORATION OF UNAIDED HOVER SCAN

If there are any artificial light sources visible with unaided vision, they may be incorporated to provide useful peripheral cueing. In many cases, such as the shipboard environment, NVG-compatible helipads, or LZs marked with chem-lights, these light sources are valuable for building a useful hover scan. Incompatible bright light sources can also be helpful for the same reason but can dramatically reduce the NVG-aided portion of the scan. The KNDZ line environment requires taxi with the non-NVG compatible searchlight and landing light on. With these lights on, the ground will be sufficiently illuminated such that that the pilot may scan underneath the NVG to control the helicopter; however, the NVG image will be significantly degraded as the goggles de-gain, making the through-the-goggle scan less useful.

706. HOVER SCAN FIXATION

Fixating on any one reference will make it difficult to detect drift in that axis due to a lack of peripheral cues, whether toward or away from that reference. To combat the tendency to fixate, the pilot must use an active hover scan, moving the NVG FOV throughout the field of regard to collect as much useful information as possible. For instance, when in a pedal turn, the pilot must continually move their scan, to include across the cockpit, to the front of the aircraft, and to the pilot’s own 45° bearing line.

Inexperienced NVG pilots struggle to maintain their hover scan during the vertical takeoff and vertical landing maneuvers. Avoid the temptation to fixate on a single reference point. Prior to starting the collective increase for the vertical takeoff, begin an active hover scan. Pilots who do not often fixate on features directly ahead of the aircraft, often resulting in aft drift. During the vertical landing, avoid the temptation to become fixated on the landing spot. Continue actively moving the scan until touchdown.

707. CONTACT PATTERN

The basics of the contact landing pattern do not change between daytime VFR and NVG aided flight; however, the pilot will need to rely on different cues to effectively maintain an acceptable flight profile. The pilot must integrate both visual and basic instrument elements into the scan. If the pilot attempts to rely primarily on outside cues as they do during the daytime, the lack of peripheral cues and limited FOV can induce spatial disorientation and failure to maintain acceptable parameters of flight. The pilot must always reinforce the outside scan by referring to the flight instruments. The following sections will discuss techniques to help avoid spatial disorientation and poor flight profiles by incorporating the NVG Integrated Scan.

1. **Transition to Forward Flight.** The transition to forward flight requires a combination of outside visual cues and elements of the ITO profile. Specifically, the pilot should incorporate the RADALT, attitude indicator for nose attitude, and airspeed indicator. The outside scan is used to eliminate unwanted drift, ensure proper ground track, and obstacle avoidance. The primary hazard during this maneuver is an unrecognized rate of descent as the aircraft transitions to forward flight. This risk is compounded in low light level conditions and in the presence of obscurants. Pilots should ensure a smooth nose attitude change to no greater than 5° to 7° nose down until the aircraft is safely clear of the deck, prioritizing an altitude over airspeed profile.

2. **Crosswind.** The lack of optical flow and visual cues will necessitate a vigilant scan of the rate instruments. Establish a smooth coordinated turn, trim for airspeed, and ensure a positive rate of climb prior to scanning outside for desired ground track to downwind. Over reliance on outside visual scan may lead to attitude deviations.

3. **Downwind.** Altitude and airspeed are still reliant on an instrument scan. The outside scan is primarily to maintain desired ground track and will require scanning ahead of and under the aircraft. The pilot may need to move body position to look around cockpit obstructions or across the cockpit to help find the LZ or other useful outside references.

4. **Base Turn.** The base turn is a complex maneuver requiring adjustments of many flight parameters simultaneously. The pilot must intelligently shift the focus between instruments and outside scan at the appropriate times throughout the maneuver. Upon reaching the abeam, the pilot must momentarily shift focus to the instrument scan to establish and maintain the parameters for the approach. Establish an appropriate rate of descent, trim in a decelerating attitude, and center the ball. Maintenance of these parameters is more difficult without peripheral cues, so a vigilant inside and outside scan is paramount. The pilot must not neglect to shift the scan continuously between outside references and instrument references to ensure the aircraft remains on an appropriate track to final.

With the outside scan, visualize a flight path that will lead the aircraft to intercept final. Ground reference points can be useful to determine an appropriate path. Adjust angle of bank as necessary to arrive on final. Throughout the base turn, regularly cross check the VSI, RADALT, BARALT, airspeed, and ball.

5. **Final.** Approaching final, the scan will be primarily visual while referencing specific instruments to ensure appropriate closure rate and glideslope. The PNAC should assist the PAC by maintaining an instrument scan and providing the PAC with altitude and rate instrument callouts. Emphasis should be placed on RADALT and VSI. As the aircraft gets closer to the deck, the VSI can be helpful with combating any "ground rush" illusion, which is common in low light environments.

The PAC must maintain a scan of the spot to judge glideslope. Use the front side of the spot as the stationary reference for the sight picture. Techniques for judging daytime glideslope, like envisioning a chalk line through the air from the helicopter to the spot or treating the front of the spot as an HSI glideslope deviation bar will continue to work at night.

During daytime approaches, groundspeed is judged based on peripheral cueing from motion parallax and optical flow. This process is done on a nearly subconscious level. With the loss of peripheral cueing on NVGs, the PAC must now consciously incorporate a scan laterally to the side of the aircraft to detect ground speed and therefore, closure rate. Some pilots prefer to scan for ground speed at the 45° bearing. The area shown in Figure 7-3, between the instrument panel and the door frame works well for this. Other pilots also like to incorporate a scan out the window to the abeam of the aircraft to pick up groundspeed cues. The PAC will need to scan back and forth between the spot to judge glideslope and laterally to the side to judge groundspeed. Fixation on the spot can cause deviation from preferred closure rate. Fixation laterally can cause deviation from glideslope and lineup.

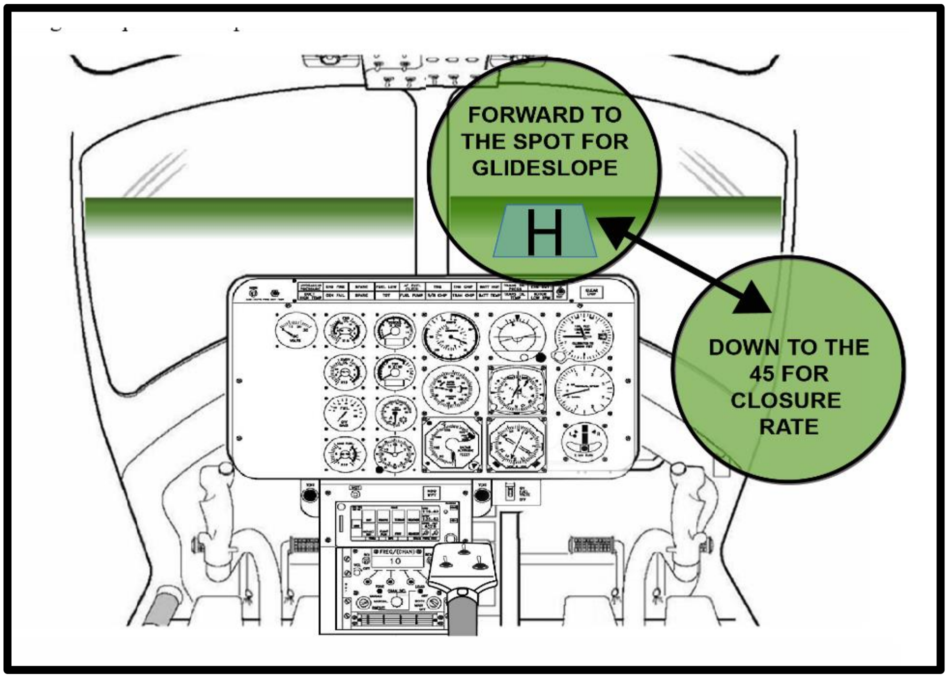


Figure 7-3 NVG Final Approach Scan Locations

CHAPTER EIGHT
NVG MANEUVERS

800. SCOPE

This FTI will provide amplifying information specific to TH-57 helicopter operations, as well as in-depth discussion of the NVG Integrated scan and its application to individual maneuvers. The Contact FTI is the primary source for all maneuver parameters, and “the numbers” will be the same for all maneuvers, whether performed during the day or on NVGs unless otherwise specified.

801. VERTICAL TAKEOFF

1. **Maneuver Description**. A vertical takeoff enables the pilot to transition from the ground to a 5-foot hover in ground effect.

2. **Application**. Vertical takeoff procedures are the same as those done in day or night unaided flight with the addition of the NVG scan.

3. Procedures

Reference Familiarization FTI Chapter 4.

4. Amplification and Technique

a. The NVG scan should be forward on the horizon moving to the 45° position on the flying pilot’s side to prevent fore/aft and sideward drift.

b. The pilot should move their scan actively to avoid fixation. Due to the lack of peripheral cueing, fixation will generally result in drift parallel to the direction of scan.

5. Crew Resource Management

PAC scans outside the aircraft as PNAC scans instruments while backing up PAC for drift and altitude corrections. Example: PNAC voices *“Stop Left,”* PAC responds, *“Roger Correcting.”* while making appropriate control inputs.

6. Common Errors and Safety Notes

a. Failure to move the NVG scan in a proper or vigilant manner.

b. NVG scan fixation too close to the helicopter.

c. Failure to notice and correct drift due to scan fixation.

d. Failure to neutralize the cyclic prior to ascending causing forward, aft, or lateral drift resulting in an erratic ascent.

e. Rushing initial takeoff.

f. Failure to maintain constant heading.

802. HOVERING

1. **Maneuver Description**. Hovering is a maneuver in which the helicopter is maintained in nearly motionless flight over a reference point with constant heading and altitude.

2. **Application.** Hovering is the unique flight characteristic giving the helicopter its versatility and capability, and the maneuver used to perform most helicopter missions. This skillset will provide the foundation for fast rope, rescue hoist, or maritime interdictions to moving vessels.

3. **Procedures**

Reference Familiarization FTI Chapter 4.

4. **Amplification and Techniques**

a. A stable NVG hover is a learned skill due to the lack of peripheral cueing and a reliance on monocular cues. This will require adjusting hover references.

b. The PAC must scan between several reference points to detect drift.

c. Scan references will need to be tailored to the ambient light level and quality of references within the immediate vicinity of the aircraft. On low light nights, the pilot’s scan will need to remain closer to the aircraft due to lack of scene detail further away.

d. Reference points should be stationary and distinct objects and should include those close to the aircraft and away from the aircraft towards the horizon.

e. The pilot should move their scan actively to avoid fixation. Due to the lack of peripheral cueing, fixation will generally result in drift parallel to the direction of scan.

f. To detect fore/aft drift, scan to a reference point abeam or 45° position.

g. To detect lateral drift, scan to a reference point forward.

h. Control hovering altitude and attitude with small and smooth corrections.

i. Reference to the RADALT may be used to verify hover height.

5. Crew Resource Management

PAC scans outside the aircraft while PNAC scans instruments, backing up PAC for drift and altitude corrections. Example: PNAC voices *"Drifting Left,"* PAC responds *"Roger Correcting"* while making appropriate control inputs.

It is important that the PNAC maintains a partial NVG scan to detect aircraft drift or motion not recognized by the PAC.

The PNAC should check gauges, caution lights, and fuel prior to the transition to forward flight.

6. Common Errors and Safety Notes

a. Scan fixation causing fore/aft and lateral drift in the direction of scan.

b. Inadvertent heading changes due to cyclic displacement in the direction of scan.

c. Aft and upward drift due to a forward-fixed scan, causing parallax monocular cueing illusions and lack of peripheral cues.

d. Failure to recognize spatial disorientation that may be caused by the 40° FOV.

e. Failure to maintain a constant hover altitude.

f. Failure to recognize drift and to take corrective action.

WARNING

> Hovering/landing in open areas of grass, sand, or snow may be disorienting due to blowing grass, sand or snow, and the lack of a stationary reference point. Extended hovering in these conditions is highly discouraged.

803. TURN ON SPOT/CLEARING TURN

1. **Maneuver Description.** A turn on the spot is a maneuver in which the helicopter is rotated about its vertical axis while maintaining a position over a reference point.

2. **Application**. Turns on the spot and clearing turns enable the pilot to clear the area prior to each takeoff, to change the direction of taxi, and to improve his/her control coordination.

3. Procedures

Reference Familiarization FTI Chapter 4.

4. Amplification and Techniques

a. To scan on the 45° position, look with the NVGs in an area on the windscreen between the egress handle and instrument glare-shield on that side.

b. A cross-cockpit scan in the direction of turn may be helpful. Ensure the NVG scan is actively moving elsewhere to account for lack of peripheral cueing.

c. Tail rotor equipped helicopters tend to climb in a left turn on the spot and descend in a right turn. Anticipate these tendencies with collective to maintain a constant altitude.

d. Anticipate wind effects.

5. Crew Resource Management

PNAC aids the PAC as described for hovering and aids the PAC in clearing the aircraft and obstacle avoidance.

Utilize cues from the PNAC for altitude and drift information.

6. Common Errors and Safety Notes

a. Scan fixation causing fore/aft and lateral drift in the direction of scan.

b. Excessive or erratic rate of turn caused by over-controlling the rudder pedals.

c. Failure to maintain a constant altitude.

d. Failure to maintain position over the reference point.

e. Tendency to drift aft and up during clearing turns due to failure to scan in the direction of turn.

WARNING

Due to the limited NVG FOV and the increased effort required to scan the entire field of regard, the crew must make a vigilant effort to scan for obstacles while operating close to the ground to maintain proper clearance.

804. NVG TRANSITION TO FORWARD FLIGHT

1. **Maneuver description.** The transition to forward flight enables the pilot to gain airspeed and altitude from a hover.

2. **Application.** This maneuver enables the pilot to perform a safe transition from a hover to forward flight. The unique risks of the night environment will prioritize safe ground clearance over minimizing time spent in the caution area of the height velocity diagram. Refer to the TH-57 NATOPS Part I, Chapter 4, Height Velocity Diagram and Figure 8-1.

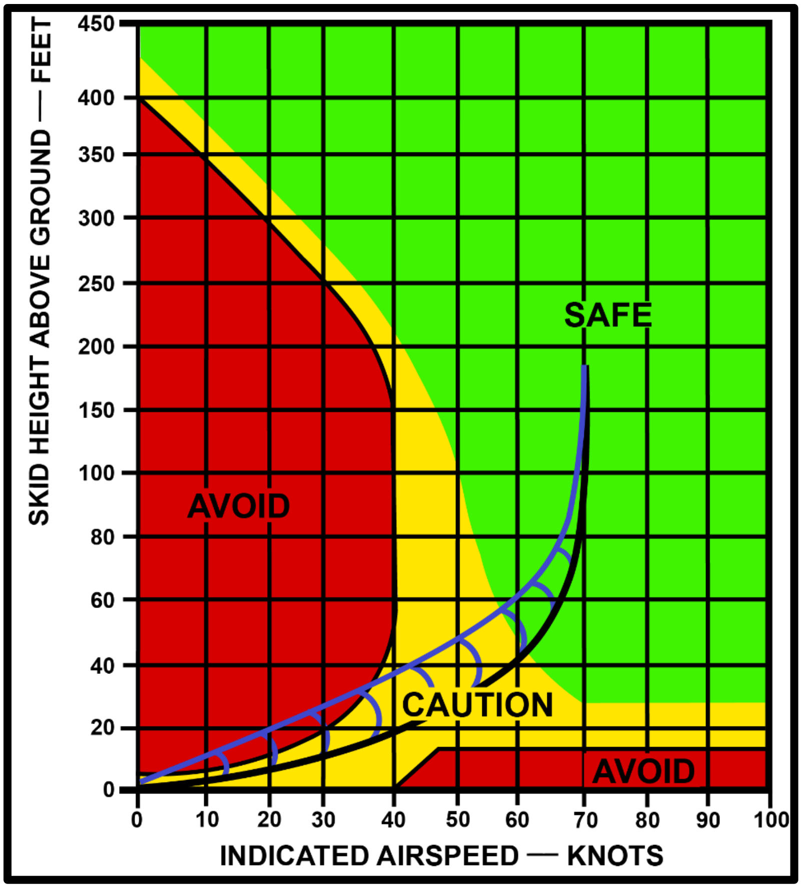


Figure 8-1 NVG Takeoff Envelope (Blue Hashed Area) vs. Normal Takeoff Profile (Black)

3. **Procedures**

   a. From a stable hover, begin forward motion by displacing the cyclic to no more than 5° to 7° nose down referencing the attitude indicator.

   b. Simultaneously, increase collective pitch with a smooth, positive pressure, maintain heading with tail rotor pedals.

   c. As translational lift is reached, adjust flight controls to maintain the proper climb attitude.

d. Intercept normal transition to forward flight profile.

e. Reference Familiarization FTI Chapter 4.

4. Crew Resource Management

a. PNAC reports “Caution panel clear, gauges green, torque is ___%, clear___” on ICS prior to forward flight.

b. PNAC reports “Three positive rates of climb, airspeed off the peg” when appropriate.

c. PNAC reports “200 feet clear left/right” and then either “anti-collision lights on” for operations at the OLF or “landing light/searchlight off” for takeoff from lighted airfields.

5. Amplification and Techniques

a. Note MSL altitude of landing zone (LZ) / intended point of landing (IPL) and up-wind (run-in) heading to provide a reference for appropriate pattern checkpoints.

b. Maintain runway alignment until reaching 65 KIAS by using a visible reference point on the horizon directly in front of the helicopter.

c. An altitude over airspeed takeoff (like an ITO profile) is recommended to ensure that a positive rate of climb is established as the helicopter begins to accelerate.

d. The primary scan for the PAC should be outside.

e. The PNAC should scan outside and inside to provide the PAC with performance instrument readings, including VSI and nose attitude.

6. Common Errors & Safety Notes

a. Failure to establish aircraft in a 5-foot hover prior to transition.

b. Excessive forward cyclic resulting in a nose low attitude (> than 7° nose down) and excessive power requirements.

c. Failure to anticipate “blowback” and trim nose attitude, causing the nose to pitch up.

d. Reducing power as the aircraft accelerates through translational lift, thus slowing the rate of climb.

e. Failure to select a reference point on the horizon to maintain ground track.

f. Failure to note zone altitude and reciprocal headings for pattern establishment.

805. NVG NO HOVER TAKEOFF

1. **Maneuver Description.** The no hover takeoff enables the pilot to safely transition from the ground to forward flight while avoiding the dangers of a degraded visual environment (DVE), such as from zones with dust, sand, or snow. The unique risks of the night environment will prioritize safe ground clearance over minimizing time spent in the caution area of the height velocity diagram. Refer to the TH-57 NATOPS Part I, Chapter 4, Height Velocity Diagram and Figure 8-1.

2. **Application**. The no hover takeoff is an alternative to the vertical takeoff and normal transition to forward flight. It is employed during degraded visual environments such as blowing snow, soil/sand, or other particulate matter stirred up by the rotor wash generated by hover flight.

WARNING

> When lifting from zones with dust, snow, or other debris, it is paramount that the pilot control nose attitude to avoid excessive nose down. This is to prevent the aircraft from remaining too close to the ground during the transition to forward flight. Taking off within a dust/snow cloud, especially when coupled with LLL conditions, can cause a loss of spatial orientation and result in CFIT.

3. **Procedures**

Reference Familiarization FTI Chapter 4.

4. **Crew Resource Management**

a. PNAC reports "Caution panel clear, gauges green, torque is ___%, clear___" on ICS on the deck prior to takeoff.

b. PAC may request torque calls in 5% increments from PNAC.

c. PNAC reports “Three positive rates of climb, airspeed off the peg” when appropriate.

d. PAC reports “Clear of the cloud” as applicable.

e. PNAC reports “200 feet clear left/right” and then either “anti-collision lights on” for operations at the OLF or “landing light/searchlight off” for takeoff from lighted airfields.

5. Amplification and Technique

a. Neutralize the controls and ensure the collective is full down. Ensure twist grip is full open, N_r at 100%, and then establish an NVG scan.

b. Apply smooth, upward pressure on the collective. Do not hesitate or stop once collective pull has started until reaching prescribed torque value as rotor wash will quickly begin lifting debris into the air.

WARNING

A slow power pull and hesitation to begin a forward climb may cause the aircraft to become enveloped in dust/snow/sand, leading to spatial disorientation and possible CFIT.

c. As collective is pulled, apply simultaneous forward cyclic and left pedal to transition into translational lift. Until clear of the cloud, reference the attitude indicator to maintain climb out attitude. This ensures whiteout/brownout conditions remain behind the aircraft. Maintain heading with pedals.

d. Use trim to establish the 5-7º nose down attitude to prevent an excessive nose low attitude and aircraft settling when near the ground.

e. Maintain prescribed torque until 200 feet AGL.

f. Avoid fixation on the torque gauge. Emphasis should be on maintaining climb power and a positive VSI.

6. Common Errors and Safety Notes

a. Failure to neutralize controls prior to takeoff.

b. Failure to maintain heading.

c. Failure to maintain a positive and constant climb out power and appropriate nose attitude, allowing the helicopter to drift close to the ground increasing the likelihood of CFIT in brownout/whiteout conditions.

d. Failure to apply sufficient forward cyclic to stay ahead of the rotor wash/dust cloud and inducing a vertical climb.

806. NVG APPROACHES

Maneuver Description. NVG approaches whether normal or steep enable a pilot to transition to hover or no hover landing over a specific point. The approach is designed around landing under low light level (LLL) conditions with no visible horizon (e.g., shipboard landings or austere landing zones). Because of the limited visual cueing provided during an NVG approach, this can be one of the more difficult procedures to execute in a helicopter. It is therefore paramount to establish good CRM and employ solid procedural knowledge during NVG landings.

807. NVG NORMAL APPROACH

1. **Application.** The normal approach is a transition maneuver which allows the helicopter to arrive simultaneously at zero groundspeed and hover altitude over a preselected spot with a maximum margin of safety. It is designed to minimize the amount of time spent in a flight envelope where the probability of a safe autorotation is questionable (determined from the H-V diagram.

2. **Procedures**

Reference Familiarization FTI Chapter 4.

3. **Crew Resource Management**

    a. PAC may request PNAC to call the abeam position.

    b. PNAC backs up PAC by calling out altitude, airspeed and VSI through the base turn.

    c. PNAC backs up PAC by calling out RADALT and VSI on final.

    d. PNAC reference VSI to ensure descent rates are not excessive call for a wave-off if VSI indicates greater than 800 fpm on final.

    e. PNAC secures anti-collision light on final when operating at an OLF or confirms landing light, searchlight and position lights are on IAW the RWOP.

    f. PNAC should be prepared to assume controls in the event of goggle failure or vertigo/disorientation.

4. **Amplification and Technique**

    a. During an NVG approach, the NVG Integrated Scan will lean heavily towards the instruments on downwind until reaching the 90° position. Use outside scan for managing ground track.

b. The ***“pause”*** portion of ***“power, pedal, pause”*** is used to ensure a 500-fpm rate of descent is set and that an instrument scan is established to commence the descending, decelerating turn.

c. Passing abeam, the spot will be outside the field of regard. Rather than attempting to look for the spot, the pilot should be focused on establishing flight parameters using an instrument scan until the spot returns to the field of regard.

d. During the base turn, the PAC will have to shift the focus between an outside scan towards the spot to manage ground track and an instrument scan to maintain a coordinated turn and appropriate descent rate to arrive on final.

e. Once on final, PAC utilizes an NVG scan laterally and forward of the aircraft to determine closure rate and maintain line up with the intended point of landing. Once below 50 KIAS, use visual references to manage closure instead of the airspeed indicator.

NOTE

The groundspeed indicator on the GTN-650 may be referenced by the PNAC to aid in managing closure rate.

f. As the aircraft approaches the spot, scene detail will begin to increase. This may induce a “ground rush” illusion as detail becomes more apparent. Use the VSI to ensure acceptable rate of descent.

g. At approximately 75 feet AGL, the glare-shield may start to cover the bottom of the landing spot and will eventually cover all the intended point of landing. PAC should utilize a forward and lateral scan utilizing other visual references after this occurs.

h. As the aircraft decelerates along the back side of the power curve and power increases to control rate of descent, anticipate pendulum effect. Expect to trim forward cyclic to maintain skid level attitude.

5. Common Errors and Safety Notes

a. Improper entry altitude and airspeed, especially at the 180° position.

b. Failure to set a 500-fpm rate of descent at the 180° position.

c. Attempting to visually acquire the spot just beyond the abeam position and failing to reference the flight instruments, resulting in improper rates of descent and AOB.

d. Failure to establish proper runway/LZ alignment, angling towards the spot or failing to account for winds. This is caused by insufficient reference to outside scan.

e. Failure to properly establish a decelerating nose attitude resulting in either excessive airspeed on final or approaching HOGE conditions.

f. Failure to scan throughout the field of regard or fixating on a particular reference.

g. Failure to scan laterally resulting in excessive closure rate after intercepting the course line.

h. Failure to scan forward to the spot resulting in poor glideslope control.

i. Failure to recognize pendulum effect, resulting in excessive nose up attitude and arriving in a HOGE short of the spot.

j. Outside scan fixation to one side of the aircraft resulting in landing to the left/right side of the intended landing spot.

k. Landing short of the spot due to keeping the spot in the same position relative to the windscreen throughout the approach (aka “spotting the deck”).

l. Arrival at the intended point of landing either above or below the 5-feet hover height due to lack of learned NVG hover altitude cues.

808. NVG STEEP APPROACH

1. **Maneuver Description.** The steep approach is accomplished at a higher glideslope angle than a normal approach.

2. **Application.** The steep approach enables the pilot to land in a confined area or to clear obstacles along the approach path. It can also be used to minimize exposure to DVE by minimizing rotor downwash interaction with the ground along short final. It is a power-controlled approach utilized when a more tightly controlled approach is required.

3. **Procedures**

Reference Familiarization FTI Chapter 4.

4. **Crew Resource Management**

a. PAC may request PNAC to call the abeam position and 50 feet prior to reaching 300 feet AGL.

b. PNAC backs up PAC by calling out altitude, airspeed, and VSI through the base turn.

c. PNAC backs up PAC by calling out RADALT and VSI on final.

d. PNAC reference VSI to ensure descent rates are not excessive, call for a wave-off if VSI indicates greater than 800 fpm.

e. PNAC secures anti-collision light on final when operating at an OLF or confirms landing light and searchlight are on IAW the RWOP.

f. PNAC should be prepared to assume controls in the event of goggle failure or vertigo/disorientation.

5. **Amplification and Technique**

a. During an NVG Steep Approach, the NVG Integrated Scan will lean heavily towards the instruments on downwind until intercepting final. Use outside scan for managing ground track.

b. The ***"pause"*** portion of ***"power, pedal, pause"*** is used to ensure a 500-fpm rate of descent is set and that an instrument scan is established to commence the descending, decelerating turn.

c. Passing abeam, the spot will be outside the field of regard. Rather than attempting to look for the spot, the pilot should be focused on establishing flight parameters using an instrument scan until the spot returns to the field of regard.

d. During the base turn, the PAC will have to shift the focus between an outside scan towards the spot to manage lineup and an instrument scan to maintain a coordinated turn and appropriate descent rate to arrive on final at 300' AGL.

e. On final, enter the approach when the spot reaches the appropriate reference above the glare-shield. Smoothly reduce collective and cross check the VSI to ensure the aircraft begins to descend. Scan laterally and forward of the aircraft to determine closure rate and maintain line up with the intended point of landing. ***Use power to manage glideslope/VSI, and cyclic to manage closure rate.***

NOTE

The groundspeed indicator on the GTN-650 may be referenced by the PNAC to aid in managing closure rate.

f. As the aircraft approaches the spot, scene detail will begin to increase. This may induce a "ground rush" illusion as detail becomes more apparent. Use the VSI to ensure acceptable rate of descent.

NOTE

> The limitations of NVGs can make glideslope and closure rate management challenging, especially in LLL conditions. Consideration should be given to keeping the VSI in the scan throughout final. As the aircraft descends on glideslope, the VSI should be gradually decreasing.

g. Between approximately 75-150 feet AGL (depending on glideslope), the glare-shield may start to cover the bottom of the landing spot and will eventually cover all the intended point of landing. PAC should utilize a forward and lateral scan utilizing other visual references after this occurs.

6. **Common Errors and Safety Notes**

a. Improper entry altitude and airspeed, especially at the 180° position.

b. Failure to set a 500-fpm rate of descent at the 180° position.

c. Attempting to visually acquire the spot just beyond the abeam position and failing to reference the flight instruments, resulting in improper rates of descent and AOB.

d. Failure to establish proper runway/LZ alignment, angling towards the spot or failing to account for winds. This is caused by insufficient reference to outside scan.

e. Failure to properly establish a decelerating nose attitude resulting in either excessive airspeed on final or approaching HOGE conditions.

f. Waiting too long for glideslope entry and approaching vertically on final.

g. Failure to scan throughout the field of regard or fixating on a particular reference.

h. Failure to scan laterally resulting in excessive closure rate or after intercepting the course line.

i. Excessive descent rate on final due to lack of reference to VSI and visual altitude cues.

j. Failure to scan forward to the spot resulting in poor glideslope control.

k. Stair stepping the approach through improper or late power application as the aircraft decelerates.

l. As the aircraft decelerates along the back side of the power curve and power increases to control rate of descent, anticipate pendulum effect. Expect to trim forward cyclic to maintain skid level attitude.

m. Maintain a rate of closure such that excessive control inputs to stay on the glideslope can be avoided. Large control inputs close to the ground are undesirable, unnecessary and can be dangerous.

n. Failure to recognize pendulum effect, resulting in excessive nose up attitude and arriving in a HOGE short of the spot.

o. Outside scan fixation to one side of the aircraft resulting in landing to the left/right side of the intended landing spot.

p. Landing short of the spot due to keeping the spot in the same position relative to the windscreen throughout the approach (aka "spotting the deck").

q. Arrival at the intended point of landing either above or below the 5-feet hover height due to lack of learned NVG hover altitude cues.

809. WAVE-OFF – POWER ON

1. **Maneuver Description.** The wave-off enables the pilot to terminate an approach or descent and transition to a normal climb.

2. **Application.** The wave-off is a transition from a low power, descending flight condition to a power-on climb.

3. **Procedures**

Reference Familiarization FTI Chapter 4.

4. **Crew Resource Management**

a. PAC or PNAC initiates wave-off, using appropriate procedures, if uncomfortable with the maneuver or condition of landing zone is in doubt.

b. PAC initiates or PNAC calls for a wave-off if glideslope becomes excessive and/or rate of descent exceeds 800 fpm at airspeed less than 40 KIAS.

c. PAC performs wave-off when a crewmember calls *"Wave-off."*

d. PAC and PNAC ensure twist grip is positioned to Full Open.

e. PAC/PNAC monitors rotor rpm, TOT and Torque.

f. PAC makes appropriate radio call, as required, upon establishing positive rate of climb and balanced flight.

g. PNAC ensures ANTI-COLLISION light is turned back on if secured prior to wave-off while operating at OLF.

5. **Amplification and Techniques**

a. Shift the Integrated NVG Scan towards the flight instruments during the wave-off procedure to ensure that the aircraft begins safely climbing away from the ground.

b. Reference the attitude indicator to set the nose approximately on the horizon until the aircraft has accelerated to 70 KIAS.

6. **Common Errors and Safety Notes**

a. Failure to recognize unsafe parameters necessitating a wave-off.

b. Excessive nose forward attitude resulting in an acceleration instead of a climb.

c. Failure to ensure appropriate torque setting to maintain a climb at 500 to700 fpm.

d. Failure to scan rate instruments.

e. Over reliance on an outside scan.

810. VERTICAL LANDING

1. **Maneuver Description.** A vertical landing enables the pilot to land from a hover.

2. **Application.** Land the helicopter by maintaining the hover attitude and smoothly lowering the collective until the skids contact the ground and the weight is smoothly transferred from the rotor to the skids.

3. **Procedures**

Reference Familiarization FTI Chapter 4.

4. **Amplification and Technique**

a. The primary challenge to conducting NVG Vertical Landings is the reduced FOV and poor distance/altitude estimation inherent to NVG flight. This can cause the pilot to be unsure of the actual distance from the skids to the ground.

b. Use an overlapping outside NVG Hover Scan to avoid fixation on any one reference. Reference fixation can cause drift in the axis of the NVG.

5. **Common Errors and Safety Notes**

a. Poor scan or scan fixation causing drift during touchdown.

b. Failure to continue to apply smooth downward pressure on the collective, resulting in the aircraft getting "hung up" prior to touchdown. This is exacerbated by poor distance estimation inherent to NVG use.

c. Anticipating ground contact and lowering collective too quickly, resulting in a firm landing.

811. NO HOVER LANDING

1. **Maneuver Description.** The no hover landing enables the pilot to safely terminate an approach to a landing without transitioning to a hover.

2. **Application**. The no hover landing is an alternate termination procedure used in conjunction with the normal and steep approaches. A no hover landing is used during operations when the landing visibility will be reduced by the rotor wash, where HIGE or HOGE is not possible, or when termination to a hover is not desirable.

3. **Procedures**

Reference Familiarization FTI Chapter 4.

4. **Amplification and Technique**

a. The primary challenge to conducting NVG No Hover Landings is the reduced FOV and poor distance estimation inherent to NVG flight. This can cause the pilot to be unsure of the actual distance from the skids to the ground.

b. As the helicopter approaches the landing spot, adjust closure rate and rate of descent to continue down the glideslope to the intended point of landing. The NVG Integrated Scan should be almost entirely outside, scanning laterally and down to the spot.

c. With the descent and closure rates under control, continue the descent through the hover altitude. The helicopter will begin to enter ground effect at approximately 30'AGL, but it will be felt most below 10'AGL. This will necessitate continued downward pressure on the collective to "push through" ground effect.

d. As the helicopter descends through five feet of altitude transition to the NVG Hover Scan. This will enable the pilot to easily correct heading and drift while eliminating the tendency to over control the descent.

5. **Common Errors and Safety Notes**

a. Maintaining a high descent rate on short final, necessitating large power applications to arrest rate of descent.

b. Not anticipating ground effect and allowing the descent to stop, resulting in a hover.

c. Failure to eliminate drift due to scan fixation.

d. Allowing the nose to yaw due to scan fixation, often turning in the direction of scan.

e. Anticipating ground contact and lowering collective too quickly, resulting in a firm landing.

f. Failing to level the skids as the aircraft approaches the ground, resulting in landing on the heels or stopping forward progress prior to landing. This is often induced by "ground rush," poor distance estimation and/or failure to correct attitude following pendulum effect.

812. QUICK STOP

1. **Maneuver Description.** Quick stop is a coordinated deceleration of the helicopter while maintaining constant heading and altitude.

2. **Application.** The quick stop enables the pilot to develop the control coordination required to decelerate the helicopter as quickly as possible while keeping the helicopter in a safe flight envelope.

3. **Procedures**

a. Maintain 500 feet AGL and accelerate to 100 KIAS on the downwind.

b. At the 180º position begin a descending turn towards the course-line and maintain balanced flight.

c. Arrive at the 90º position at 300 feet AGL and 100 KIAS.

d. Intercept the course-line at 100 KIAS and continue the descent to 50 feet AGL. Establish crosswind corrections as necessary.

e. Stabilize momentarily at 50 feet AGL, 100 KIAS, then coordinate down collective and aft cyclic to slow the aircraft while maintaining constant heading and altitude.

f. Slow to 45 KIAS airspeed.

g. Recover by coordinating up collective and forward cyclic while maintaining constant heading and altitude.

h. Accelerate to 70 KIAS and resume a normal climb.

4. **Amplification and Technique**

   a. Establish the helicopter downwind at 500 AGL and 100 KIAS. From the 180º position (approximately the downwind boundary), at 500 feet AGL and 100 KIAS, commence a descending turn to arrive at the 90º position at 300 feet AGL and 100 KIAS.

   b. Continue the turn and descent, maintaining safe obstacle clearance, to arrive on the course-line at 50 feet AGL and 100 KIAS.

   c. Once the altitude and airspeed have stabilized, smoothly coordinate down collective with aft cyclic and right rudder to slow the helicopter as rapidly as possible while maintaining a constant heading and altitude. Simultaneous coordination of flight controls is required.

   d. Commence the recovery by coordinating forward cyclic, up collective and left rudder in sufficient time to recover the aircraft at 50 feet AGL and 45 KIAS. Check engine instruments and accelerate to the 70 KIAS climb airspeed.

   e. A recovery initiated at approximately 48 KIAS should enable the aircraft to decelerate to 45 KIAS.

   f. The more collective is lowered in coordination with aft cyclic inputs, the faster the aircraft will decelerate. If collective is not lowered enough, the aircraft may not slow to 45 KIAS prior to the upwind field boundary.

5. Common Errors and Safety Notes

   a. Avoid the common tendency to let the airspeed get excessively slow during the recovery.

   b. Avoid the common tendency to descend or balloon on entry due to poor cyclic and collective control coordination.

   c. The quick stop shall be initiated by the middle of the field.

   d. Safe obstacle clearance shall be maintained throughout the entire maneuver.

APPENDIX A
GLOSSARY

ACCOMMODATIVE EYE FATIGUE. Fatigue associated with NVG flight; the eyes continuously and automatically focusing and refocusing to offset binocular adjustment errors or differences in intensifier tube resolution.

AIDED. A term used to describe those times when NVDs are being used. The human visual system is being aided by these devices.

ALBEDO. The ratio of the amount of light reflected from a surface to the amount of incident light.

APPARENT DISC. The sunlit surface area of the moon that can be seen from the earth.

ASTIGMATISM. A defect of the refractive system of the eye (usually due to corneal irregularity). With this condition, rays from a point fail to meet in a focal point resulting in a blurred and imperfect image.

ASTRONOMICAL TWILIGHT. The period of time which begins in the morning when the center of the sun is geometrically 18 degrees below the horizon in the east and ends in the evening when the center of the sun is geometrically 18 degrees below the horizon in the west.

AUTOMATIC BRIGHTNESS CONTROL (ABC). One of the automatic gain control circuits found in second and third generation NVG devices. It attempts to provide consistent image output brightness by automatic control of the microchannel plate voltage.

AUTOMATIC GAIN CONTROL SYSTEM (AGC). Comprised of the automatic brightness control and bright source protection circuits. Is designed to maintain image brightness and protect the user and the image tube from excessive light levels. This is accomplished by controlling the gain of the intensifier tube.

BEGIN MORNING NAUTICAL TWILIGHT (BMNT). That time when the true altitude of the center of the sun (rising) is 12 degrees below the horizon. Solar illuminance levels currently are compatible with NVG operations. Illuminance levels when the sun is higher than 12 degrees below the horizon will most likely not be compatible with NVG operations.

BLOOMING. Common term used to denote NVG “de-gain” or “shutdown” of all or part of the NVG image due to exposure of the NVG image intensifier tube to an incompatible bright light source.

BRIGHT SOURCE PROTECTION (BSP). One of the automatic gain control circuits found in second and third generation NVG devices. This circuit serves to protect the intensifier tube and the user by controlling the voltage at the photocathode.

BROWN-OUT. Condition created by blowing sand, dust, etc., which can cause the pilots to lose sight of the ground. This is most associated with landings in the desert or in dusty LZs.

CIVIL NAUTICAL TWILIGHT. The period which begins when the true altitude of the center of the sun is six degrees below the horizon in the east and ends when the sun is geometrically 6 degrees below the horizon in the west. Illuminance level is approximately 3.40 lux and is above the usable level for NVG operations.

CLIMB TO COPE. Increasing altitude from the terrain flight profile to increase reaction time and comfort level.

DEGOGGLE. The action of placing the AN/AVS-9 in the up and stowed position for unaided flight operations.

DIOPTER. A measure of the refractive (light bending) power of a lens.

DONNING. Those actions involved in physically attaching the NVGs to the helmet.

DEGRADED VISUAL ENVIRONMENT (DVE). A condition describing an LZ that is obscured by dust, snow, sand, or other particulate matter thrown airborne by rotor wash, otherwise known as Brownout or Whiteout.

ELECTROLUMINESCENT (EL). Light emission that occurs from application of an alternating current to a layer of phosphor.

ELECTRO-OPTICS (EO). The term used to describe the interaction between optics and electronics, leading to transformation of electrical energy into light or vice versa.

END EVENING NAUTICAL TWILIGHT (EENT). That time when the true altitude of the center of the sun (setting) is 12 degrees below the horizon. Solar illuminance levels approximate 10-3 Lux at this time and are compatible with NVG operations.

FOOT-CANDLE (fc or ft-c). A measure of illuminance; specifically, the illuminance of a surface upon which one lumen is falling per square foot.

FOOT-LAMBERT (fL or ft-L). A measure of luminance; specifically, the luminance of a surface which is receiving an illuminance of one foot-candle.

GAIN. When referring to an image intensification tube, the ratio of the brightness of the output in units of foot-lambert, compared to the illumination of the input in foot-candles. A typical value for a GEN III tube is 25,000 to 30,000 fL/fc. A “tube gain” of 30,000 fL/fc provides an approximate “system gain” of 3,000. This means that the intensified NVG image is 3,000 times brighter to the aided eye than that of the unaided eye. Regarding FLIR systems, it pertains to the temperature range corresponding to the displayed dynamic range.

GOGGLE. The action of placing the AN/AVS-9 in the down and operating position and/or configuring aircraft lighting for NVG compatibility.

ILLUMINANCE. Also referred to as illumination. The amount, ratio, or density of light that strikes a surface at any given point.

IMAGE INTENSIFIER. An electro-optic device used to detect and intensify optical images in the visible and near infrared region of the electromagnetic spectrum for the purpose of providing visible images. This component is composed of the photocathode, MCP, screen optic, and power supply. It does not include the objective and eyepiece lenses.

INCANDESCENT. Refers to a source that emits light based on thermal excitation, e.g., heating by an electrical current, resulting in a broad spectrum of energy that is dependent primarily on the temperature of the filament.

INFRARED. That portion of the electromagnetic spectrum in which wavelengths range from 0.7 microns to 1 millimeter. This segment is further divided into near infrared (0.7 to 3.0 microns), mid infrared (3.0 to 6.0 microns), far infrared (6.0 to 15 microns), and extreme infrared (15 microns to 1 millimeter).

LOW LIGHT LEVEL. Ambient illumination less than 0.0022 lux.

LUMEN. A measurement of luminous flux equal to the light emitted in a unit solid angle by a uniform point source of one candle intensity.

LUMINANCE. The luminous intensity (reflected light) of a surface in a given direction per unit of projected area. This is the energy used by NVGs.

LUX. A unit measurement of illumination. The illuminance produced on a surface that is one-meter square from a uniform point source of one candle intensity or one lumen per square meter.

MESOPIC VISION. A combination of photopic and scotopic vision in low light, but not quite dark conditions. An intermediate state of night adaptation achieved while flying on NVGs.

MICROCHANNEL PLATE. A wafer comprised of more than 6 million specially treated microscopic glass tubes designed to multiply electrons passing from the photocathode to the phosphor screen in second and third generation intensifier tubes.

MICRON. A unit of measure commonly used to express wavelength in the IR region; equal to one millionth of a meter.

MINIFICATION. A decrease in the apparent or perceived size of an object, or of its image in relation to the object. A negative power lens will create this effect, i.e., dialing in too much negative diopter in the NVG eyepiece lens. The resultant decrease in the apparent size of an object in relation to the object leads to increased difficulty with inflight distance estimation.

MORNING NAUTICAL TWILIGHT. The time when the true altitude of the center of the rising sun is 12 degrees below the horizon.

NANOMETER (nm). A unit of measure commonly used to express wavelength in the visible and near IR region; equal to one billionth of a meter.

NIGHT VISION DEVICE (NVD). An electro-optical device used to provide a visible image using the electromagnetic energy available at night (e.g., AN/AVS-9 NVG, FLIR systems, etc.).

PHOTON. A quantum (basic unit) of radiant energy (light).

PHOTOPIC VISION. Vision produced as a result of the response of the cones in the retina as the eye achieves a light adapted state (commonly referred to as day vision).

REFLECTIVITY. The fraction of energy reflected from a surface.

SCOTOPIC VISION. That vision produced because of the response of the rods in the retina as the eye achieves a dark-adapted state (commonly referred to as night vision).

SITUATIONAL AWARENESS (SA). Degree of perceptual accuracy achieved in the comprehension of all factors affecting an aircraft and crew at a given time.

STARLIGHT. The illuminance provided by the available (observable) stars in a subject hemisphere. Depending upon the reference document sited, the inclusion of airglow illumination, and the prevailing atmospheric conditions, a moonless night provides between 0.001 and 0.002 lux illuminance. Although starlight illumination alone provides 0.00022 lux illumination, this value does not include the illumination available from airglow and other atmospheric effects present on a moonless night. For standardization purposes, in this manual the term “starlight” will be used to refer to the illumination available on a clear, moonless night sky. Further, “starlight illumination” will be defined by the value 0.001 lux and “starlight overcast” will be defined by the value 0.0001 lux.

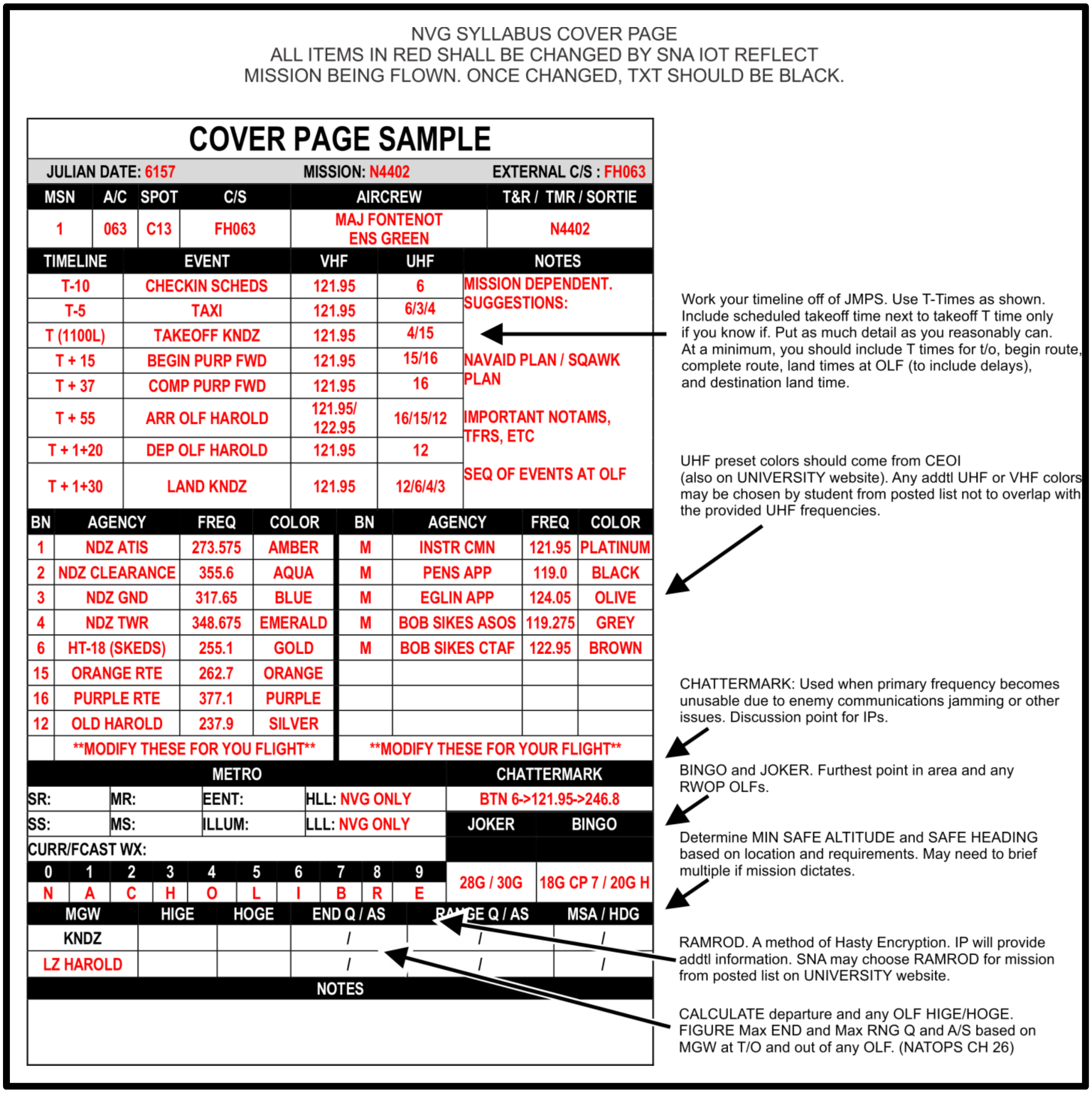
STEREOPSIS. Visual system binocular cues that are used for distance estimation and depth perception. Three-dimensional visual perception of objects.

UNAIDED. Term used to describe those times when NVDs are not being used/worn as the visual system is not being aided by these devices.

WAVELENGTH. The distance in the line of advance of a wave from any one point to the next point of corresponding phase; is used to express electromagnetic energy including IR and visible light.

WHITEOUT. A condition like brown-out but caused by blowing snow.

APPENDIX B
FORMATION AND NVG COVER SHEET



NVG SYLLABUS COVER PAGE
ALL ITEMS IN RED SHALL BE CHANGED BY SNA IOT REFLECT
MISSION BEING FLOWN. ONCE CHANGED, TXT SHOULD BE BLACK.

COVER PAGE SAMPLE

JULIAN DATE: 6157 MISSION: N4402 EXTERNAL C/S : FH063

MSN	A/C	SPOT	C/S	AIRCREW	T&R / TMR / SORTIE
1	063	C13	FH063	MAJ FONTENOT ENS GREEN	N4402

TIMELINE	EVENT	VHF	UHF	NOTES
T-10	CHECKIN SCHEDS	121.95	6	MISSION DEPENDENT. SUGGESTIONS:
T-5	TAXI	121.95	6/3/4	
T (1100L)	TAKEOFF KNDZ	121.95	4/15	
T + 15	BEGIN PURP FWD	121.95	15/16	NAVAID PLAN / SQAWK PLAN
T + 37	COMP PURP FWD	121.95	16	
T + 55	ARR OLF HAROLD	121.95/ 122.95	16/15/12	IMPORTANT NOTAMS, TFRS, ETC
T + 1+20	DEP OLF HAROLD	121.95	12	
T + 1+30	LAND KNDZ	121.95	12/6/4/3	SEQ OF EVENTS AT OLF

BN	AGENCY	FREQ	COLOR	BN	AGENCY	FREQ	COLOR
1	NDZ ATIS	273.575	AMBER	M	INSTR CMN	121.95	PLATINUM
2	NDZ CLEARANCE	355.6	AQUA	M	PENS APP	119.0	BLACK
3	NDZ GND	317.65	BLUE	M	EGLIN APP	124.05	OLIVE
4	NDZ TWR	348.675	EMERALD	M	BOB SIKES ASOS	119.275	GREY
6	HT-18 (SKEDS)	255.1	GOLD	M	BOB SIKES CTAF	122.95	BROWN
15	ORANGE RTE	262.7	ORANGE				
16	PURPLE RTE	377.1	PURPLE				
12	OLD HAROLD	237.9	SILVER				
	MODIFY THESE FOR YOU FLIGHT			**MODIFY THESE FOR YOUR FLIGHT**			

METRO				CHATTERMARK	
SR:	MR:	EENT:	HLL: NVG ONLY	BTN 6->121.95->246.8	
SS:	MS:	ILLUM:	LLL: NVG ONLY	JOKER	BINGO
CURR/FCAST WX:					

0	1	2	3	4	5	6	7	8	9	JOKER	BINGO
N	A	C	H	O	L	I	B	R	E	28G / 30G	18G CP 7 / 20G H

MGW	HIGE	HOGE	END Q / AS	RANGE Q / AS	MSA / HDG
KNDZ			/	/	/
LZ HAROLD			/	/	/

NOTES

Work your timeline off of JMPS. Use T-Times as shown. Include scheduled takeoff time next to takeoff T time only if you know if. Put as much detail as you reasonably can. At a minimum, you should include T times for t/o, begin route, complete route, land times at OLF (to include delays), and destination land time.

UHF preset colors should come from CEOI (also on UNIVERSITY website). Any addtl UHF or VHF colors may be chosen by student from posted list not to overlap with the provided UHF frequencies.

CHATTERMARK: Used when primary frequency becomes unusable due to enemy communications jamming or other issues. Discussion point for IPs.

BINGO and JOKER. Furthest point in area and any RWOP OLFs.

Determine MIN SAFE ALTITUDE and SAFE HEADING based on location and requirements. May need to brief multiple if mission dictates.

RAMROD. A method of Hasty Encryption. IP will provide addtl information. SNA may choose RAMROD for mission from posted list on UNIVERSITY website.

CALCULATE departure and any OLF HIGE/HOGE. FIGURE Max END and Max RNG Q and A/S based on MGW at T/O and out of any OLF. (NATOPS CH 26)

Figure B-1 Cover Page Sample

THIS PAGE INTENTIONALLY LEFT BLANK