COMPARISON OF NIGHT VISION GOOGLES AND FLIR SYSTEMS IN AIRBORNE APPLICATIONS

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ABSTRACT

Infrared sensors have very important usages on airborne vehicles for navigation, night targeting and observation. There exist basically two types of night vision device on aircrafts. Night Vision Google (NVG) and Forward Looking Infrared (FLIR). NVG senses reflected infrared (IR) energy and FLIR senses radiated IR energy from objects. This paper gives technical and tactical comparison of infrared sensors (NVG and FLIR) used in aircrafts. It is critical for the flight safety and mission effectiveness to understand the limitations of both sensors and to thoroughly plan for their usage. Comprehensively understanding how NVG and FLIR systems integrate will allow aircrews to maximize the utility of the two sensors while minimizing their own risks.

Keywords: Night Vision, NVG, Thermal Imaging, Infrared, FLIR.

HAVA PLATFORM UYGULAMALARINDA GECE GÖRÜŞ GÖZLÜĞÜ VE TERMAL SISTEMLERIN KARŞILAŞTIRILMASI

ÖZET

Kızıl ötesi (Infrared-IR) sensörler hava platformlarında seyrüsefer, gece hedef takip ve gözetleme amaçlı önemli kullanıma sahiptirler. Hava araçlarında gece görüş için temelde iki cihaz kullanılmaktadır. Bunlar Gece Görüş Gözlüğü (NVG) ve İleri Bakan Termal Sistem (FLIR)'dir. NVG nesnelerden yansıyan IR ışınları algılarken, FLIR nesnelerden ışıyan IR ışınları algılamaktadır. Bu makalede, hava araçlarında kullanılan NVG ve FLIR kızıl ötesi sensör sistemlerinin teknik ve taktik karşılaştırılması yapılmaktadır. Her iki sensörün üstünlüklerini, farklarını ve kısıtlamalarını bilmek uçuş emniyeti ve görev etkinliği açısından önem arz etmektedir. Bu sebeple, her iki sensörü teknik ve taktik olarak tamamıyla anlamak, mürettebatın sensörlerden azami faydalanmasına ve risklerini asgariye çekmelerine katkı sağlayacaktır.

Anahtar Kelimeler: Gece Görüş, Termal Görüş, Kızılötesi. FLIR, NVG.

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Makalenin geliş tarihi: 24.09.2009 ***Kabul tarihi:*** 23.11.2009

1. INTRODUCTION

Looking back over the past 1000 years, we notice that infrared (IR) radiation itself was unknown until 209 years ago when Herschel’s experiment with thermometer was first reported (Herschel, 1800). He built a crude monochromator that used a thermometer as a detector so that he could measure the distribution of energy in sunlight (Herschel, 1800). The Latin prefix "infra" means "below" or "beneath." Thus "infrared" refers to the region beyond or beneath the red end of the visible color spectrum. IR imaging by day or by night has become one of the most important sensing technologies over the past 30 years. In that time, technology has advanced appreciably up to the point where the quality of IR imaging and visible light imaging is virtually indistinguishable.

The infrared region is located between the visible and microwave regions of the electromagnetic spectrum. Because heated objects radiate energy in infrared, it is often referred to as the heat region of the spectrum. All objects radiate some energy in the infrared, even objects at room temperature and frozen objects such as ice.

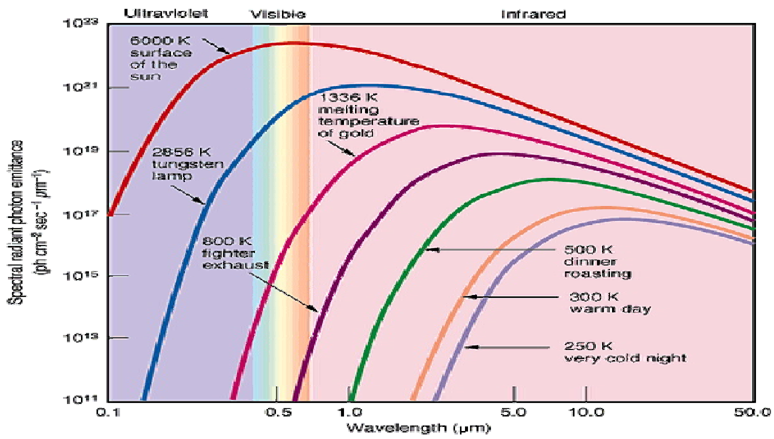

Figure 1. Optical Spectral Radiation

As shown in Figure 1, the higher the temperature of an object, the higher the spectral radiant energy, or emittance, at all wavelengths and the shorter the predominant or peak wavelength of the emissions (Koçer, 2006). Peak emissions from objects at room temperature occur at 10 µm. The sun has an equivalent temperature of 5900 K and a peak wavelength of 0.53 µm (green light). It emits copious amounts of energy from the ultraviolet to beyond the far IR region.

Human eye sees in visible light spectrum from 400 to 750 nanometres. But there are other spectral windows that our eyes can not see but IR sensors can see. There are Short Wave Infrared (SWIR) or Near Infrared (NIR) are from 800 to 3000 nanometres (0.8–3 µm). Mid-Wavelength Infrared (MWIR) is from 3000 to 5000 nanometres (3–5 µm) and Long-Wavelength Infrared (LWIR) is from 8000 to 12000 (8–12 µm).

Night-vision devices gather ambient light and intensify the image by using a photocathode device to produce electrons from the photons in the incident light. The electrons are multiplied and then used to bombard a phosphor screen that changes the electrons back to visible light. The sensors are normally configured as a monocular or binocular 'goggle' which is attached to the operator's helmet (Figure 2), and through which he views the external low-light scene (Moir and Seabridge, 2006).

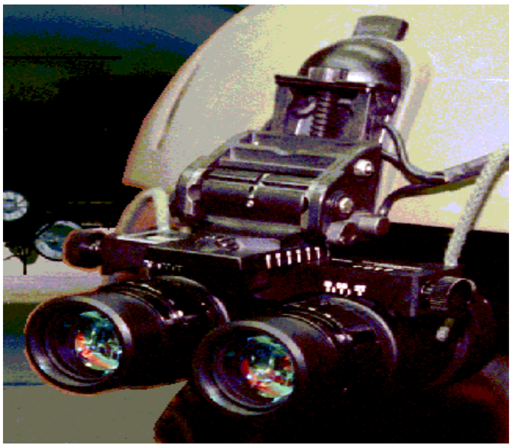

Figure 2. Night Vision Google (NVG).

2. NVG AND FLIR SYSTEMS

FLIR means Forward Looking Infrared which is more frequently used for the name of infrared or thermal systems used on airborne vehicles. NVG devices with their Image Intensifier Tubes (I^2T) senses weak near/short IR (NIR or SWIR) reflection from objects. NVG resembles human eye with the exception that human eye detects visible reflection from objects. FLIR devices with their IR detectors senses mid IR (MWIR) and/or long IR (LWIR) radiation from objects having temperature greater than 0 (zero) Kelvin. (-273°C). For NVG to operate, weak illumination sources are needed like moon and star light. NVG can not work in total darkness. On the other hand, FLIR or thermal systems do not need any light source and operate in total darkness. They only need temperature difference between object and the background to detect object (Koçer, 2006).

3. TECHNICAL COMPARISION OF NVG AND FLIR

The purpose of this section is to identify design and image differences that should be considered during mission planning and tactical applications.

3.1. Mission Requirements

NVG and FLIR systems were designed originally to address specific operational requirements: the NVG was to be used primarily to enhance situational awareness (SA), to provide for improved tactical formations, and to provide for increased maneuverability; while the FLIR was to be used primarily to enhance both day and night targeting (Figure 3).

Figure 3. FLIR vision

Figure 4. NVG vision

Both could help improve night navigation. Knowing these basic premises will help us understand why certain design decisions were made, which design constraints are important tactically, and how a particular limitation of one sensor may be offset by a particular capability of the other.

Additionally, both NVG and FLIR systems have passive sensors and thus have an advantage under certain tactical situations and threat considerations when the usage of active systems (e.g., terrain following radar) may not be advisable.

3.2. Mounting Methods

Advanced image intensification technology and good packaging design has allowed the development of a night vision goggle (Figure 4) that is light enough to be worn on a helmet or other head supported devices. This allows aircrew to view the world in a “normal” manner, and to accurately combine terrain flow with the true motion of the aircraft (Figure 5). However, the added weight and offset center of gravity (CG) can lead to fatigue. Additionally, it is critical that the NVG/helmet system fit aircrew precisely to avoid slippage during maneuvering or long flights, and to afford good look-around capability for viewing cockpit displays. FLIR technology has not progressed to a point where the system can be light enough to be head mounted. This is due in part to limitations in optical designs and in part to mission requirements (e.g., field of view/magnification changes, etc.). Additionally, current aircraft windscreen and canopy materials do not transmit wavelengths in the far-IR spectrum. Therefore, a FLIR sensor must be mounted somewhere on the aircraft frame (Figure 6) and imagery provided to aircrew either on a heads down display or heads-up via a HUD unit, or it may be projected on a head-mounted combiner.

Figure 5. NVG Normal Eye Position

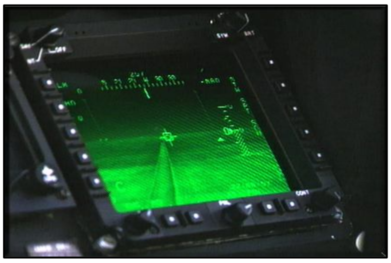

Figure 6. FLIR Position

3.3. Energy Source

Each sensor is designed to be sensitive to different regions of the electromagnetic spectrum. A NVG is designed to use reflected energy (Figure 7). Consequently, there must be a certain level of energy present in the night sky for an image to be generated. FLIR systems are designed to be sensitive to energy (Rogalski, 2003) that is radiated (i.e., thermally emitted). Thus, a FLIR operates independently of the energy present in the night sky (Figure 8). Anything that adversely affects energy prior to it reaching either sensor (e.g., heavy rain) will adversely affect the quality of the resulting images.

Figure 7. NVG Uses Reflected Energy

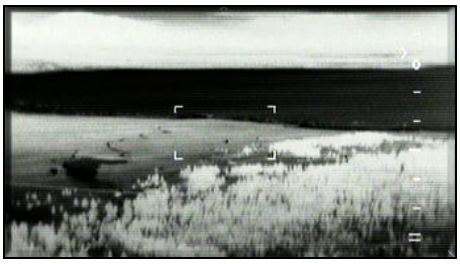

Figure 8. FLIR Uses Radiated Energy

3.4. Spectral Sensitivity

Each sensor is sensitive to a different portion of the electromagnetic spectrum. The NVG is sensitive to the visible and near-IR region (exact visible sensitivity dependent on objective filter), and FLIR systems are sensitive to longer wavelengths in the IR region (3 to 5 microns or 8 to 12 microns depending on the system type). This results in differing effects on the image due to variables such as environmental conditions and airborne particulate matter (i.e., shorter wavelengths are affected differently than longer wavelengths). It is vital for us to understand these effects for planning purposes, and for us to be able to detect and predict changes in image quality as conditions vary once airborne. This can lead to early determination of which sensor to trust, and to understand under some conditions neither sensor will provide useful information.

3.5. Image Magnification

In general, an NVG used by aircrew is designed to produce an image with one-to-one or unity magnification, which means that objects in the image are the same size as the correlating objects in the real world. This is important since the NVG is head-mounted and designed for the most part to aid in spatial orientation and situational awareness. FLIR systems generally are not designed to provide unity magnification due to targeting requirements and technical difficulties (e.g., sensor at a different location from the pilot's eye position). In fact, most FLIR systems provide various magnification selections that allow aircrew to view areas and/or objects at distances much greater than possible with the NVG.

3.6. Field of View (FOV)

The FOV of a system is determined by its optical design, and the optical design is based on mission requirements. Since most FLIR systems are designed to provide targeting information, the FOV is usually very narrow (e.g., 1°) in order to enhance image detail. FLIR systems developed for navigational use are usually designed to fit the area of a HUD (e.g., 19° by 21°). In both cases, the FOV of a FLIR system is less than that of most NVGs used in aviation (e.g., 40°) (Figure 9).

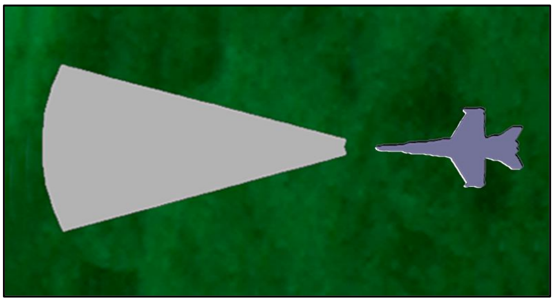

Figure 9. FOV

3.7. Field of Regard (FOR)

The operationally relevant FOR of each sensor is a result of each sensor's FOV and its mounting location. Since the NVG is head-mounted, FOR is limited by the amount of head movement available, the aircrew's position, and by viewing obstacles within the aircraft (e.g., canopy bow, glareshield, etc.). On the other hand, a FLIR sensor that has a much smaller FOV than a NVG will usually have a FOR that is much greater because of its external mounting location (Figure 10). However, an externally mounted FLIR will still have some FOR limitations due to design constraints (e.g., limits of sensor head gimbals) and mounting location effects (e.g., fuselage blanking) (Figure 11).

Figure 10. NVG Similar to unaided eye.

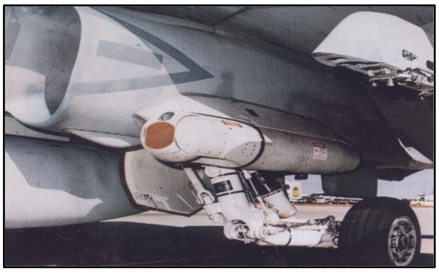

Figure 11. FLIR Sensor Head Design

3.8. Resolution/Detail

Technically, image resolution can be compared in a number of different ways and can take into account a number of different sensor combinations (e.g., sensor head capability, display capability, etc.). However, it is image detail that is important to aircrew, regardless of the stated “specification” for resolution. Therefore, image detail will be the subject of comparison and the resolution used only as a point of reference or emphasis. It is important to consider the basis for comparison and what it means tactically, otherwise it is easy to compare apples with oranges. To avoid this, the resolution comparison is divided into two parts:

Unity Magnification, a NVG image is always presented in a unity magnification format. For the most part, FLIR systems dedicated for navigation are also designed to produce an image that correctly overlays the real world when presented on the HUD (i.e., unity magnification). Even though the specifications for the rastered HUD image may indicate that the resolution is better than that presented by a NVG, looking through the HUD image into a background of cultural lights or other features may adversely affect the quality of the FLIR image. Thus the NVG image may appear to be better, given the conditions are conducive for using NVGs (Figure 12). However, as conditions change (e.g., illumination level, weather, relative moon position, etc.) the quality of each image will also change, and this can occur as quickly as a heading change.

Other than Unity Magnification is not a comparison in the strict sense of the word since the NVG image is only presented in a unity magnification format, but is added to compare the capabilities of the sensors. Typically, a Tageting FLIR (TFLIR) system is developed for tasks other than navigation (e.g., targeting, tracking, etc.), and they are designed for various FOV and magnification choices (Figure 13). These will allow aircrew to see detail at distances from the aircraft that is not possible with an NVG or Navigation FLIR (NAVFLIR). It is also possible to use a TFLIR for acquiring navigation information by slaving the image to the aircraft's heading. However, it should be noted that the image will not correctly overlay the real world (i.e., the image is not at unity magnification and it is not correctly registered). Consequently, there is an increased risk of spatial disorientation if it is attempted the TFLIR image for aggressive navigational following or maneuvering.

Figure 12. Generally better detail than NAVFLIR image on the HUD

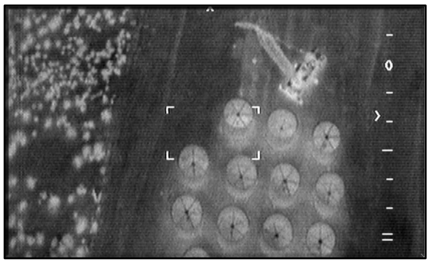

Figure 13. TFLIR provides detail at distances not possible with NVG

3.9. Color

Neither sensor is presented in natural colors. The NVG image has a saturated green or gold/green hue, depending the NVG make/model (Figure 14). The FLIR image (Figure 15) typically will be presented in shades of gray (depending on the display). However, FLIR sensors also usually have a polarity capability so that the shades can be reversed as needed to accentuate or highlight the required detail. The polarity selections include White Hot (warmer objects/areas are presented in varying shades of white and cooler objects/areas in shades of gray), and Black Hot (warmer objects/areas are presented in varying shades of gray and cooler objects/areas in shades of white).

Figure 14. Shades of Gren (NVG)

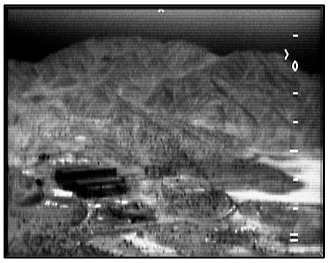

Figure 15. Shades of Gray (FLIR)

4. ENVIRONMENTAL COMPARISON NVG AND FLIR

The purpose of this section is to demonstrate how various environmental factors affect each sensor, thus showing which sensor will likely provide the most reliable information under given conditions. This information can be used during mission planning and flight briefing, and should help prepare us to make more accurate assessments of sensor function when airborne.

4.1. Effects of Illumination

Since NVGs are designed to intensify limited amounts of energy within a specific range of visible and near-IR wavelengths, the illumination level has a direct effect on the quality of the image. Either too much or too little illumination (i.e., energy) will render the image useless (Figure 16). Therefore, the goggle is only useful during nighttime, when the illumination level provides enough energy for a useful image to be produced. Since FLIR systems do not depend on illumination for their energy source, the effects of illumination are only indirectly related (e.g., thermal energy from an intense illumination source such as the sun). In general, the image presented by a FLIR system is not dependent on the illumination level (Figure 17).

Figure 16. Effects on Gain

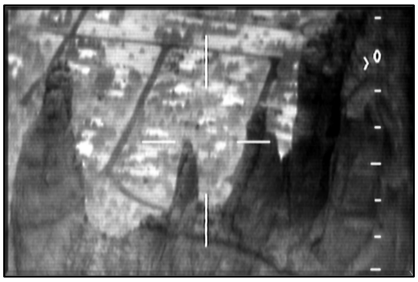

Figure 17. Few Direct Effects

4.2. Effects of Variations in Thermal Activity

Since FLIR systems use thermal energy to produce an image, variations in thermal energy have a pronounced effect (Figure 18). Small variations are required to form an image that includes content familiar to the viewer. Large variations may create distortions, thus making it difficult to identify the object or possibly masking it completely (similar to the effect noted in an NVG image when a large halo is created by a bright point light source). Variations in thermal activity only affect the NVG image when the source provides near-IR energy (e.g., skin of an aircraft after de-selecting afterburner, forest fire, etc.). In general, the NVG image is unaffected by minor variations in thermal activity (Figure 19).

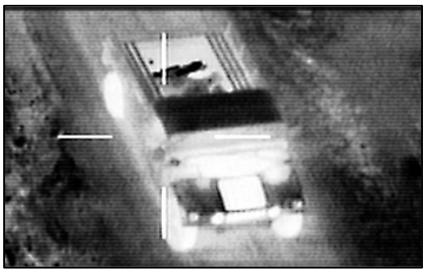

Figure 18. FLIR Image.

Figure 19. NVG Image.

4.3. Effects of Time of Day

The effects of the time of day vary for each sensor. For the NVG (Figure 20), the setting or rising sun provides energy that can adversely affect the image. Additionally, the time of night may be a factor depending on the lunar cycle and the moon's azimuth/elevation changes during the night (e.g., low angle moon effects, changes in shadowing, etc.). These effects are usually straightforward, predictable and can be incorporated into preflight planning for route selection, attack positions, etc. FLIR systems, on the other hand, are receiving energy that is undergoing constant changes throughout the daytime and nighttime, and the effects are sometimes difficult to predict (Figure 21). Objects heat and cool due to changes in the sun's position, presence of clouds, weather effects, shadowing, variation in the internal thermal activity of objects, etc. As the sun begins to set, many objects begin to approach the same relative temperature and detail can be lost. The same happens just after sunrise when some objects begin to warm to the same temperature. This is called "diurnal crossover" and is a well-known consequence of thermal imaging. The timing of the diurnal crossovers will vary depending on many factors. All of these variables make it more difficult to predict the time-of-day effects on the FLIR image and are not usually available as preflight planning data.

Figure 20. Effects of Time of Day on NVG.

Figure 21. Effects of Time of Day on FLIR.

4.4. Weather Effects

Changes in image quality caused by weather are a result of the effects on the wavelengths to which each sensor is sensitive. NVGs form an image by using reflected energy, and anything that keeps that energy from reaching the goggle will adversely affect image quality. The shorter wavelengths to which intensifier tubes are sensitive are scattered by larger particles (e.g., snow) or dense accumulations (e.g., heavy rain shower, dense fog, etc.). However, the shorter wavelengths pass fairly well through less dense accumulations (e.g., light rain or fog) and are essentially unaffected by high levels of water vapor in the air (i.e., conditions of high absolute humidity). With one major exception, the NVG responds to weather conditions just like the human eye. If the eye cannot see through it, neither can the NVG, except when a viewer with NVGs can see into or through light rain or fog. This exception, however, represents an insidious hazard. Unless aircrew are looking under the goggles and are able to see the rain or fog with the unaided eye, they can inadvertently enter an area that gradually worsens (i.e., the rain and/or fog becomes more dense) until the NVG image is rendered useless. FLIR systems are affected in several ways by the weather. Long periods of rain and/or overcast conditions can reduce thermal contrast, thereby reducing image quality. Short periods of snow can have the same effect. Both of these conditions have a more profound affect on passive emitters (e.g., terrain) than on active emitters (e.g., an operating truck). In fact, an active emitter may be more apparent and may be detected at greater ranges with an isothermal background. In addition to the effects weather may have on the thermal properties of objects, the constituents of weather (e.g., water vapor, rain, fog, etc.) will have adverse effects on the longer wavelengths to which FLIR systems are sensitive. For example, these wavelengths are very susceptible to atmospheric absorption during conditions of high absolute humidity, and, depending on the type of FLIR system, there will be differences in this susceptibility as seen in Figure 22 (Riedl, 2001). For example, in general, a system that is sensitive in the 3-5 micron range will be less susceptible to humidity than a 8-12 micron system, but both will still be adversely affected to some degree. Finally, larger aerosol particles such as fog, rain, or dust can scatter energy before it reaches the sensor, thus reducing image quality.

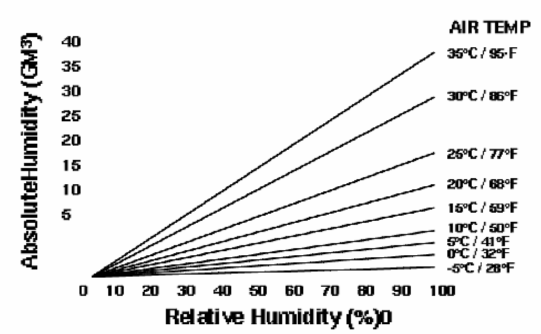

Figure 22. Weather Effects

4.5. Other Atmospheric Effects

As with weather, the effects secondary to other atmospheric constituents such as smoke, dust or haze relates to the effects on the various wavelengths to which the sensors are sensitive as seen in Figure 23 (Koçer, 2006).

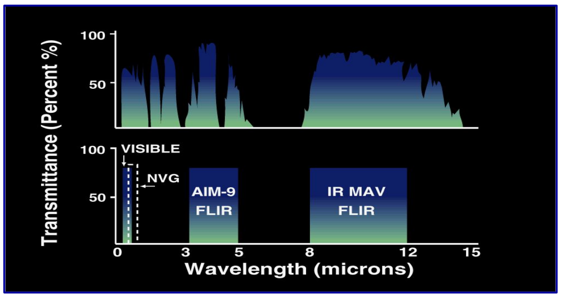

Figure 23. Other Atmospheric Effects

In general, if the wavelength to which the sensor is sensitive is roughly the same size as the airborne particles, the energy will be scattered and the image degraded. Since they are sensitive to smaller wavelengths, an NVG, generally, will be susceptible to more varied types and concentrations of airborne particulate matter than a FLIR system.

4.6. Response to Cultural Light Sources

Cultural light sources have a more pronounced affect on NVGs due to the response of intensification tubes to visible and near-IR energy (Figure 24). FLIR sensors will only be affected if the cultural lighting is hot enough for the thermal imager to detect it or if the lighting heats objects/areas enough to provide a thermal difference that is detectable (Figure 25).

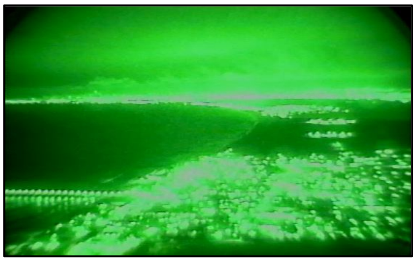

Figure 24. Culturel Light Sources with NVG.

Figure 25. FLIR Can Not Detect Light Sources Unless Thermally Significant.

4.7. Response to Thermal Sources

FLIR systems are designed to be receptive to thermal differences, whereas NVGs are designed to be responsive to reflected energy (Figure 26), which is then intensified. Therefore, in general, FLIR systems are more responsive to thermal energy sources (Figure 27). However, since NVGs are sensitive to certain IR wavelengths, and these wavelengths are present in thermal sources, the goggle may exhibit some response to these sources. For example, at certain aspects, a pilot can "see" the exhaust from a jet engine while using an NVG, even if there is not enough visible energy for it to be seen unaided.

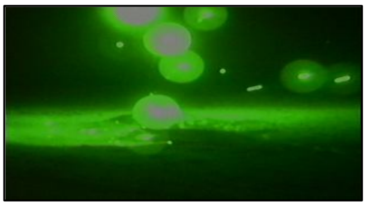

Figure 26. NVG Will Detect If Source Contains Visible and/or Near-IR Components.

Figure 27. FLIR Able to Detect Minor Differences in Thermal Activity.

4.8. Effects of Shadows

Shadows or shadowing affects both sensors but in different ways and for varied reasons. For FLIR systems, anything that prevents thermal energy from reaching a surface will result in thermal variations in the scene.

For example, areas that are shielded from thermal sources or are cooled by some other sources show as cooler spots in the FLIR image. This would include such things as the area of ground beneath the wings of a parked aircraft (Figure 28), areas shaded by trees or buildings, exposed objects cooled by a strong wind, etc. In a more broad sense, significant shading of large areas during the daytime (e.g., heavy overcast) will result in an overall loss of contrast relative to both natural objects and “inactive” man-made objects in the scene. Since NVGs function on reflected energy, anything that blocks the energy (before it reaches) the surface of interest will reduce image contrast. For example, a cloud between the moon and the area of interest will result in the area being “shadowed.” (Figure 29). Since there is less energy within the shadowed area, this area will exhibit less contrast in the NVG image. For both sensors, shadowed areas or objects may be detected at tactically relevant distances, but detail of these areas or objects within the sensor image will be reduced.

Figure 28. Effects of Shadows in FLIR.

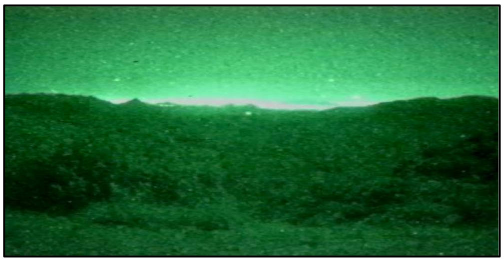

Figure 29. NVG’s Reduced Detail Inside Shadow.

5. OPERATIONAL INTEGRATION OF NVG AND FLIR

The purpose of this section is to demonstrate how the two sensors may augment each other during a mission. To accomplish this, a few tactically relevant examples will be described. It is important, when studying the descriptions, to determine whether the use of a NAVFLIR or TFLIR is appropriate. Depending on the aircraft and availability of sensors, several combinations are possible (e.g., NAVFLIR AND TFLIR, NAVFLIR only, TFLIR only, etc.). In general, a NAVFLIR will be less flexible regarding its use at any altitude and for targeting, whereas a TFLIR will provide some navigational information in addition to its targeting functions. Additionally, the type of FLIR used during the mission will affect the integration of NVGs.

Therefore, it is vital that the availability of sensors, as well as the combination of sensors, be determined prior to flight planning.

Some of the descriptions also assume that aircrews can adequately describe the differences between the images presented by the two sensors, and more importantly, can describe, for example, something in an NVG image that another crewmember or flight member can then find on the FLIR image. This may not be as easy as it sounds due to the differences in image quality and technology, but is important and may require specific training and experience.

5.1. Situational Awareness

Situational Awareness (SA) can be defined in a number of different ways, but for the purpose of this paper the definition most commonly used for research and operational applications will be used. SA is the perception of the elements in the environment within a volume of time and space, the comprehension of their meaning, and the projection of their states in the near future (Endsley, 1988).

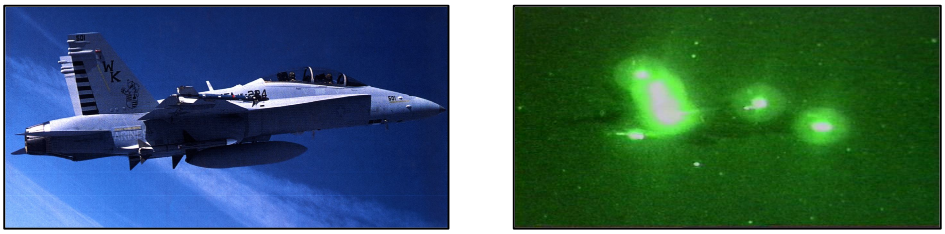

Figure 30. Situational Awareness.

Since both sensors provide visual information, they can profoundly enhance the information provided by other sources such as radar, threat warning devices and flight instruments. Furthermore, since each sensor is affected differently by external factors and each provides unique information, at least one of them is useful under most mission conditions. For example, on a high illumination night and from a medium altitude, NVGs (Figure 30) can provide information about active areas of threat, the location of other flight members, the location of other airborne aircraft (e.g., FAC, tankers, etc.), basic environmental information (e.g., mountain ranges, rivers, presence of urban areas) and a horizon that will allow aggressive maneuvering if needed. On the same night, a FLIR system will provide more detailed ground and target information than the goggle is capable of resolving at medium ranges/altitudes. The emphasis on each sensor changes as the environmental conditions change. If the moon sets during the same mission or if the enemy is using techniques to avoid detection by NVGs (e.g., turning off vehicular lights), the NVG becomes less useful and the FLIR more useful in some applications. For example, as the illumination level decreases, so does the ability of the NVG to resolve ground detail, especially at increased ranges/altitudes. Under this condition, more dependence will be placed on the FLIR system, but at the cost of more heads-down time and an increase in workload. It is very important to understand the many tradeoffs that occur when integrating these systems (e.g., usefulness of information, changes in workload, changes in crew coordination task assignments, etc.) and how they affect situational awareness.

5.2. Spatial Orientation

Maintaining spatial orientation when using any visual sensor always requires an aggressive instrument crosscheck (Biberman, 2000). However, visual sensors can significantly reduce some of the underlying effects of using instruments alone to determine orientation. For example, vertigo can result when maneuvering using only instruments, especially when scanning for other information such as weapons system status or the white phosphorous mark.

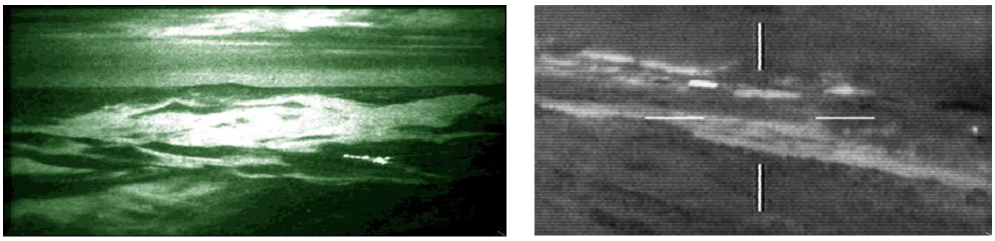

Figure 31. Spatial Orientation

NVGs provide a way for the pilot to scan the horizon, thus potentially eliminating the occurrence of vertigo. On nights when a horizon cannot be discerned with NVGs, it is possible that a FLIR can be used. However, due to the constraints of a FLIR (e.g., not unity magnification, not head-mounted, very limited field of view, etc.), it is likely that maneuverability will be reduced relative to that possible with NVGs, but still greater than possible when using flight instruments alone. In addition to the visualization of the horizon, both sensors allow aircrew to see familiar details (e.g., ridgeline, buildings, pylons, etc.) that may also be used for orientation (Figure 31).

5.3. Threat Detection/Avoidance

NVGs can be used to detect an active ground threat (e.g., muzzle flash, rocket motor, etc.) at great distances (Figure 32), but lack the resolution and magnification capability to gather much concrete information concerning the threat (e.g., number of vehicles, orientation of support structures, etc.).

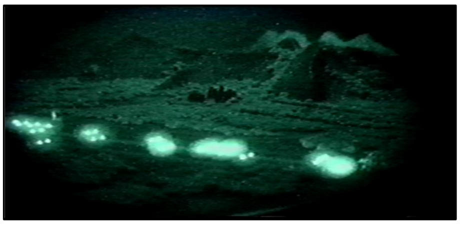

Figure 32. Detection of Active Threats.

Figure 33. Visualization of Hazard.

Once detected with NVGs, it is possible to more accurately position the FLIR and use its narrow field of view capability to gather more definitive threat information. Should the threat remain inactive until the last minute, the use of NVGs can allow a pilot to employ aggressive threat avoidance tactics, provided the conditions are adequate. In this case, the limitations of FLIR systems will not enhance maneuverability, but the area could be designated and/or videotaped to obtain vital threat suppression information, even when clear of the threat zone. Like the NVG, a FLIR may also be used to detect threat at a distance. For example, the heat generated by mobile threat vehicles (e.g., operating engines, tread friction, etc.) may alert aircrew to the presence of threat before it becomes active.

5.4. Hazard Avoidance

Having two sensors available that respond differently to the multiple environmental variables and that present information based on differing technologies will increase the likelihood of aircrews being able to detect and avoid hazards.

For example, suppose the flight plan calls for crossing wires along a portion of the route. Due to a low flight altitude and the blending of pylons into a background of mountainous terrain, it may be difficult to detect the pylons with NVGs, even when they are very close (Figure 33). On the other hand, knowing the position of the pylons relative to the route, it may be possible to see them on the FLIR display and may even be possible to detect them earlier than normal by using a narrow field of view. This possibly can be accomplished by using other cultural features that are recognizable on the display to “funnel” the FLIR field of view to the pylons. However, one hazard that is always a threat to low level operations is the presence of the wires themselves, and neither sensor is effective in detecting the actual wires.

6. CONCLUSION

As discussed in this paper, it is vital for flight safety and mission effectiveness to understand the limitations of the sensor and to thoroughly plan its use. Although the use of both sensors (NVG and FLIR) can minimize some of the tactical limitations of each individual sensor, there continue to be significant limitations that must be addressed during planning and during mission execution. These limitations make it paramount to assess any change, no matter how minor it may seem. Thoroughly understanding how NVG and FLIR systems integrate and differ will allow aircrew to maximize the utility of the two sensors while minimizing their own risks.

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