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The Ultimate Purchasing Guide for Night Vision and Thermal Imaging Systems

MUST HAVE

Second Edition

WHO IS THIS GUIDE DESIGNED FOR?

This Ultimate Purchasing Guide is a useful tool for anyone interested in or currently using a night vision or a thermal imaging device: from hunters and recreational shooters to military and law enforcement professionals. It gives a deeper insight of key technological aspects and reveals what you need to know about these systems.

WHAT DOES THIS GUIDE DO?

- Explains the meaning of key parameters: what's hidden behind numbers
- Shows why some devices are more expensive than others
- Helps choose the right product for your application
- Gives unbiased and professional "birds-eye view"

WHAT'S NEW IN SECOND EDITION?

The second edition of the ultimate purchasing guide features new topics such as types of non-uniformity correction in thermal engines, a more detailed description of what makes up the price of a night vision and thermal imaging device, and more. In addition, outdated sections from the first edition were improved along with simplified design with easier-to-read typography.

WHY USE THIS GUIDE?

Nowadays the global market offers a wide variety of night vision and thermal imaging products. Despite the fact that most information is available on the Internet, the problem remains: how do you select the device that would perfectly fit your needs and not break the budget? What performance parameters are really important? How do you navigate in the maze of specs, configurations and special terms?

WHY USE THIS GUIDE?

Imagine, just a few minutes ago you as a Buyer could be a Novice who is facing the Seller who is a Professional. We witness the imbalance or unfairness towards you, the Buyer. Because you are simply at the mercy of the Seller, making a purchasing decision which you may regret further down the road.

This Purchasing Guide will help you become a Professional in the Optical-Electronic Industry, thus talking to the Seller as an equal, asking the right questions, that lead to the right purchasing decisions. At the end of the day you'll simply enjoy your purchase which is called ...

THE BEST VALUE FOR YOUR MONEY

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Lens F-number

The objective lens is, quite literally, your window to the world of night– and thermal vision. The quality of this “window” directly affects the image you see with your device. So choose the lens wisely: you do not want to spoil the view with low-quality optics.

One of the main parameters of front lenses responsible for image quality is called **f-number**. It is also known as *f-stop*, *focal ratio* or *relative aperture*. It is the ratio of the lens' focal length and the diameter of entrance pupil (labeled “D”).

PART I. GENERAL CHARACTERISTICS: LENS F-NUMBER

The lower the f-number, the more radiation the lens captures, which is light in the case of night vision or infrared radiation for thermal imaging. Lenses with a low f-number improve overall sensitivity of your device which results in a more detailed and crisp image. Furthermore, thanks to higher sensitivity, a low f-number lens allows you to see farther and achieve better results in detection, recognition and identification of various objects.

Compare Yourself!

Both devices above are equipped with lenses of the same focal length—75mm, but different f-numbers. The device with f-number **f/1.3** is approximately **1.7 times less sensitive** than that with f/1.0 since reducing the diameter of the lens by 1.3 reduces the area of the lens by a factor of 1.69.

Low f-number: Pros and Cons.

- (+) High sensitivity, sharp and crisp image.
- (+) Longer Detection, Recognition, Identification Ranges
- (−) Increased size and weight. More expensive.

Conclusion. For best performance, choose the device in which the front lens has the smallest f-number value. However, there are a few downsides: size, weight and cost. High-sensitivity lenses are bigger, heavier and tend to be more expensive than their less sensitive counterparts. If the device's performance is your top priority then equipping it with lowest f-number objective lens is the best choice!

Optical and Digital Zoom

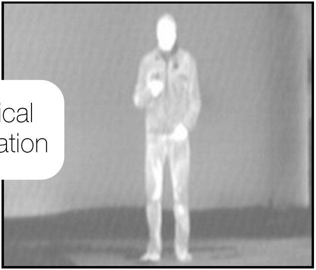
Magnification (or zoom) is the ability of an optical-electronic device to bring an object “closer” to the viewer. But by what means: optically or digitally?

Optical magnification is provided by an objective lens and directly relates to its focal length. The bigger the focal length of the lens, the greater the optical magnification. Increasing it does not have any negative effect on image quality: it stays crisp and sharp. On the other hand, the nature of digital zoom is completely different. Rather than utilizing optical capacity of the front lens, the device’s electronics does all of the work. It takes a central portion of the image that the device produces, crops and proportionally stretches it. As a result, the image quality is reduced. The reason is that digital image is made of thousands of individual pixels, the total number of which represent an object does not change in digital zooming. When switching to higher zoom factors, the device electronically enlarges the image by making the pixels bigger.

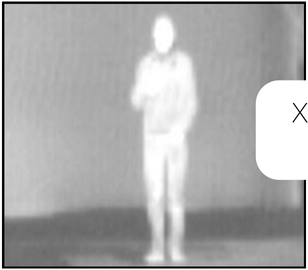
PART I. GENERAL CHARACTERISTICS: OPTICAL AND DIGITAL ZOOM

To be perfectly accurate, digital zoom is just a *simulation* of optical magnification.

Compare Yourself!



X4 Optical Magnification



X4 Digital Zoom

Sometimes manufacturers specify combined or total zoom. It is calculated by multiplying maximum optical and digital zoom factors.

If the detector (FPA) has resolution of 384x288, then at digital zoom X4 the image you see will effectively have resolution of just 96x72 pixels. It therefore becomes clear why having and using digital zoom factors higher than X4 makes little or no sense.

Optical Magnification: Pros and Cons

- (+) Crisp and ultimately sharp image at all times
- (+) No image quality loss
- (+) Longer Detection/Recognition/Identification Ranges
- (−) Increased size and weight. More expensive.

Digital Zoom: Pros and Cons

- (+) No additional parts: preserves size and weight
- (+) Implementing involves no cost
- (−) High values cause significant image quality degradation

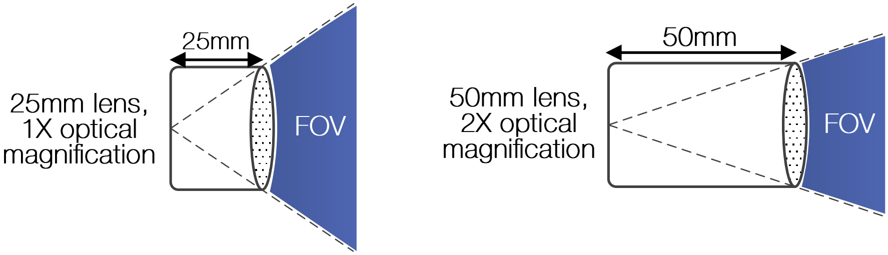
Conclusion. Most devices on the market have fixed objective focal length, and therefore fixed optical zoom, but allow the digital magnification to vary. To achieve the best results in any environment it is recommended to mainly rely on optical magnification with little aid of digital zoom.

Field of View

In optical equipment, the term *field of view* is used to quantitatively describe the observable space for a particular optical device. Field of view, or FOV for short, is measured in degrees, just like angles. Its value shows how much of the surrounding space is spanned or “seen” by the front lens of your device. For thermal imaging systems FOV is expressed by two numbers (horizontal and vertical) while in night vision devices it is generally represented by a single number (e.g. 40°), since the night vision image is circular and thermal image is rectangular.

It is noteworthy that there is a direct relation between field of view and optical magnification. We have already discussed that higher optical zoom is achieved by increasing the lens’ focal length. However, it imminently narrows the lens’ spatial viewing capacity. The term “field of view” is also related to *situation awareness*. In the context of optics, it is a qualitative description of your understanding and perception of space. The larger the FOV of the device, the better your situation awareness.

Compare yourself!



Conclusion. It is recommended to use a higher FOV lens for general observation on small or medium distances to provide greater viewing area. However if you plan to use your device mostly for long-range aiming or object recognition, then optical zoom is your #1 priority.

FPA Resolution

Thermal imaging sensors, otherwise known as FPA (focal plane array) or thermal detector, is the true heart of every thermal imaging system. A thermal imager works pretty much the same way your digital camera does. The only difference is that a digital camera senses visible radiation, while most thermal imagers work in long wave-infrared range: it reacts to temperature related IR radiation, not light.

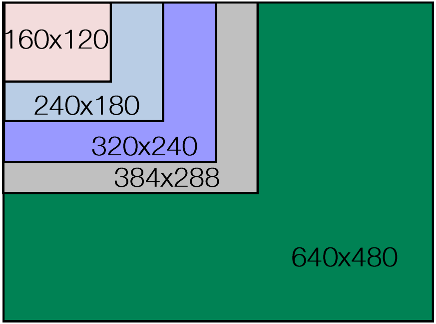
The building block of every FPA is a device called *microbolometer*. It is indeed “micro” because its size is 4 times smaller than average thickness of human hair. Microbolometers are pixels of the detector and make up an array where each of those tiny devices change its electrical resistance depending on wavelength of radiation it receives. Changes of resistances from all microbolometers are then electronically processed and used to generate a thermal image. Naturally, the more microbolometers a thermal detector has, the most crisp and detailed the image you will see. In other words, we are talking about *resolution* of the detector.

PART II. THERMAL IMAGING SYSTEMS: FPA RESOLUTION

FPA resolution is a key performance parameter that directly reflects how far and how clear you will be able to see with your thermal device. Typical values for resolution are 320x240, 384x288 and 640x480. Below we present a comparison for thermal detectors performance with different FPA resolutions.

Compare yourself!

** low-resolution, low-end thermal imagers equipped with poor quality optics and equally poor quality FPAs lead to significant degradation of device's sensitivity and overall performance.*



Conclusion. FPA resolution has profound influence on the price of a thermal imager. High resolution models deliver exceptional performance and image quality but cost considerably more than lower-spec units. Choose FPA resolution based on the environment where the thermal unit would be used, operating distances and your budget.

Thermal Sensitivity

It is not a secret that image quality is one of the most tangible parameters that gives you the first impression and may then affect your decision in regards to purchasing a device. So which parameters are directly responsible for image quality? There are four: objective lens f-number, FPA resolution, display with an optimal resolution of 800x600 pixels and last but not least—thermal sensitivity.

Thermal sensitivity is the quantitative description of how well a thermal device distinguishes temperature differences. It is expressed in mK (milliKelvin or one-thousandth of a Kelvin). A lower numerical value (in mK) indicates higher sensitivity, because the device can discern even smaller differences in temperature. Typical value of FPA sensitivity is 50mK, which means that the detector can differentiate objects if the difference in their surface temperatures is 50mK or more, e.g. 11.95°C and 12°C. Here it is specifically stated "FPA sensitivity", not overall sensitivity. Remember we mentioned the connection between front lens f-number and sensitivity?

Overall System Sensitivity of a thermal device is in fact a product of FPA sensitivity and front lens f-number squared:

System Sensitivity = Detector Sensitivity x (Lens F-Number)^2

Some manufacturers of thermal imaging devices may not reveal the system sensitivity of their devices, claiming only high sensitivity of their detectors while conveniently omitting the f-number of the front lenses that the devices are equipped with.

Example: For a thermal device with FPA sensitivity of 50mK and front lens f-number f/1.4, the device's sensitivity is 50x$(1.4)^2$ = 98mK. The result shows **reduction** in detecting capabilities **by half** compared to that with f/1.0 front lens.

Conclusion. Always ask about FPA sensitivity and front lens f-number values. This is the only way you can assess how the device really performs. A thermal detector's sensitivity will be seriously compromised if paired with a poor quality lens system.

Refresh Rate

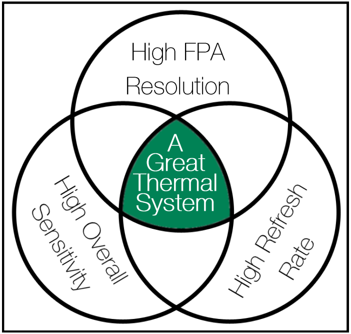
Performance of a thermal imaging system is described by yet another parameter: *refresh rate*. It is expressed in Hertz (or frames per second, fps) and indicates how many times video image refreshes in one second. The same idea applies to your home TV or a computer screen.

Thermal imaging detectors with refresh rates of 25Hz and above deliver superior responsiveness, dynamic, “fluid” and “live” video image with no lags. This is particularly important for successful observation and detection of moving objects. Detectors with a lower refresh rate display video at a much slower rate, which results in choppy video stream which people may find uncomfortable or even impossible to watch. It is quite obvious that low frame rate thermal imagers are no match for a full-featured unconstrained units.

A 50Hz thermal imaging device delivers 5.5 times smoother *video image than a 9Hz unit.*

So why are low frame rate thermal imagers still on the market? In certain countries there are export restrictions which limit exportability of thermal imagers with refresh rates above 9Hz. Always ask your supplier for *detailed export information*.

Conclusion. You can now see that a thermal device's performance rests on these three pillars: FPA resolution, overall sensitivity and refresh rate. For best results, choose the device with the highest refresh rate.



Non-Uniformity Correction (NUC)

Non-Uniformity in a thermal imaging device is a temperature-dependent image degradation that occurs in the FPA due to different responsivity of individual pixels to incoming radiation. In order to deal with this negative effect, a NUC technique needs to be introduced. Non-uniformity correction is a sequence of algorithms that compensate the difference in responsivity of the individual pixels of FPA. There are 3 major NUC techniques with their own pros and cons.

1. Shuttered

NUC is performed by means of periodic covering the detector with an internal mechanical shutter for about 1 to 3 seconds. This process occurs automatically and without warning once every 30 seconds to 5 minutes.

- (+) Inexpensive
- (+) Provides more accurate thermal image
- (−) Loud shutter clicks
- (−) Least reliable
- (−) Poor shock resistance
- (−) Halts device's operation for up to 3 seconds

2. Shutterless with manual NUC

No mechanical shutter. To perform NUC, an operator has to manually cover and uncover the lens with an object of uniform temperature (e.g. lens cover) when image degrades and press a designated button on the device.

- (+) Inexpensive
- (+) Silent and reliable
- (+) Shock-resistant
- (−) Halts observation during NUC
- (−) Tedious and repetitive “cover-press-uncover” procedure
- (−) Cannot be used remotely. An operator has to be nearby.

3. Shutterless with Automatic NUC

Thanks to the combination of factory performed calibration and a set of sophisticated image processing algorithms, the need in manual NUC is eliminated. NUC is performed automatically, instantly, continuously.

- (+) Uninterrupted device operation
- (+) Silent and reliable
- (+) Shock-resistant
- (+) Operator is not distracted to do calibration
- (+) Device can be used in remote areas
- (−) More expensive

When choosing a thermal imaging device, always ask about NUC techniques implemented in the device as there is always a trade-off between convenience of use and price.

FPA Gain Control

Imagine yourself walking in a forest early morning, just before sunrise. Cool air envelopes the trees, bushes and the ground so that the environment has uniform ambient temperature. It is still pretty dark so you choose to navigate using your brand new thermal imager. To travel safely you would need to **increase FPA sensitivity (gain)** on your device to better detect temperature difference of surrounding objects. Now leave the forest and put yourself in an environment with many temperature-contrasting objects (very hot and very cold), here you may then need to **reduce FPA sensitivity** to level out the displayed image and achieve the best scene perception.

These two simple examples prove the necessity for a thermal imaging device to have the ability to manually control FPA gain.

**Please note, that manual gain control in thermal imaging systems should not be confused with manual gain control in night vision devices: these functions are completely different.*

Compare yourself!

Conclusion. Manual gain control offers you flexibility in optimizing your device's performance according to environmental conditions. Nowadays many thermal imagers come standard with this feature. Choose the one that is equipped with manual gain control because you never know when you will need it.

Detection, Recognition, Identification (DRI)

"How far can I see with it?" - is the most frequent question asked when someone is looking to buy a thermal imaging device.

Let's examine what exactly Detection/Recognition/Identification ranges are (or DRI for short) and what is involved in estimating them.

Detection - The perception of an object image as being present at a particular location and distinct from its surroundings.

Recognition - The determination that an object belongs to a particular functional category (e.g., animal, human, truck, tank, etc.).

Identification - The most detailed level of description of a particular object within a functional category (unarmed male civilian, four-door truck).

Based on Johnson's criteria table, 3 pixels are needed to detect an object, 6 to recognize, and 12 to identify it. This approach gives a 50% probability to successfully accomplish a task of object detection/recognition/identification and ...

corresponds to maximum DRI values. To increase the said probability to 90%, the number of pixels needs to be increased by 1.8 times, and more specifically to 5.4 pixels for detection, 10.8 for recognition and 21.6 for identification.

DRI values listed in the device's specifications are generally given for reference only and may not correlate with results obtained in real-world conditions, as in some cases many more pixels need to be distinctively seen to successfully detect/recognize/identify an object. This in turn will significantly impact the distances at which an object is detected/recognized/identified.

DRI values are affected by a number of factors that are related to environment, object, thermal system itself and the operator who uses it. The lists of factors are not exhaustive, other factors may also affect DRI values.

PART II. THERMAL IMAGING SYSTEMS: DRI

Human Factors
Training
Experience
Expectations for targets
Stress
Concurrent task load
Clarity of vision
Fatigue
Set electronic zoom
Set FPA gain level
Set display brightness
Set image polarity
Optics focusing
Cleanliness of optics
Placement of device

Thermal System Characteristics
Thermal sensor pixel pitch
Thermal sensitivity
Optical magnification
Objective lens aperture (f-number)
Display type, size and resolution
Non-Uniformity Correction (NUC)

Object Characteristics
Object-Scene temperature contrast
Camouflage
Object speed and direction
Object Size

Environment Characteristics
Fog
Rain
Haze
Sand
Other climatic obscurities
Atmospheric attenuation (e.g. atmospheric turbulence caused by solar heating)
Air density and temperature

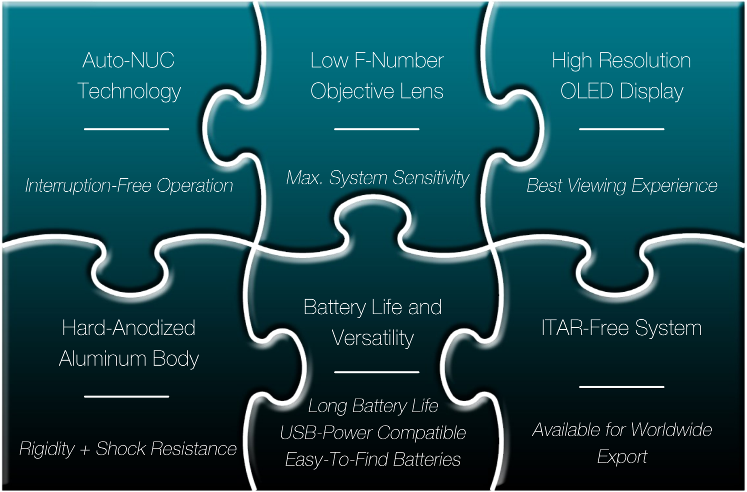
Detection

Recognition

Identification

Conclusion. DRI figures in devices' specifications are maximum values and sometimes they are artificially (and misleadingly) increased to attract your attention. Always compare at least 3-4 similar products and keep in mind the factors that affect DRI ranges.

What Makes a Thermal Imager Great?



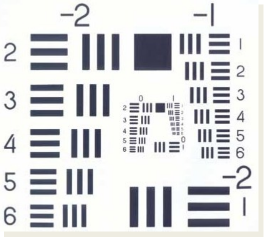
PART III. NIGHT VISION SYSTEMS

Figure Of Merit (FOM)

The paramount component that the night vision industry revolves around is the IIT - Image Intensifier Tube. The primary function of this high-tech device is to collect ambient light, intensify it several thousand times and transmit it to the viewer.

IITs are graded by a number of characteristics. The two major ones are *Resolution* and *Signal-to-Noise Ratio (SNR)*. Together they make up a collective parameter that defines overall performance of an IIT. It is called *Figure of Merit (FOM).*

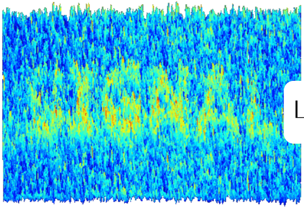
Resolution is expressed in line pairs per millimeter (lp/mm) and experimentally measured for each tube on the factory. An OEM customer can also evaluate the IIT's resolution by looking at the test pattern with a special field tester. During the test, an operator has to clearly discern both horizontal and vertical lines of certain patterns and then refer to an original tube's datasheet. Resolution starting at 60 lp/mm ...



and above delivers high levels of detail of a night vision image. Keep in mind that resolution alone is not fully responsible for the performance of an IIT. *Signal-to-noise ratio (SNR)* has a significant impact as well. SNR is a dimensionless value that determines a tube's performance in low-light conditions. SNR is calculated by dividing signal amplitude that reaches the operator's eye by the perceived noise level. A good performing tube has a value of SNR starting at 20 and above. This means that signal received by the tube is 20 times more pronounced than the background noise.

Compare yourself!

High SNR



Low SNR

FOM is calculated as a product of image intensifier's resolution and signal-to-noise ratio. FOM usually ranges from a few hundreds for Generation 1 to over 1800 for a high-end Gen. 3 tubes:

FOM = Resolution x Signal-to-Noise Ratio

Conclusion. FOM value indicates the level of performance delivered by an IIT. Price tag on night vision systems is directly reflected by FOM of the tube(s) installed in any given device.

Manual Gain Control

Gain control in a night vision device is the ability to change the image intensifier tube's intensity depending on medium- or low-light conditions. Models of night vision devices that lack manual gain control may cause the user to experience brightness misbalance due to the fact that IIT works at its maximum gain all the time. This effect may lead to the so-called "night blindness effect" and is particularly critical for monocular-type systems: when one eye of an operator looks into the darkness while the other sees an uncomfortably brighter night vision image.

Most Mil. Spec. night vision systems are equipped with manual gain control: by rotating the knob, an operator adjusts IIT's intensity and therefore achieves optimal image brightness and better perception.

Compare yourself!

MANUAL GAIN: LOW

MANUAL GAIN: OPTIMAL

MANUAL GAIN: HIGH

Conclusion. Manual gain control is a great feature available in the variety of night vision devices on the market. It adds a little bit to the cost and many professional users consider it a wise investment. In return, it offers desired flexibility to adjust the image intensifier tube's brightness and achieve optimal performance in any environment.

Auto Gated Night Vision

Auto gating is one of the best performance-enhancing options you can have in a night vision device. It is an electronic feature of an image intensifier tube that instantaneously adjusts image contrast even in rapidly changing lighting conditions: flashing lights, explosions and so on. At the same time, it improves the tube's protection from bright sources.

Auto gating is widely regarded as a "life saver" especially among military and law enforcement professionals. If exposed to a bright source of light, the *ABC** and *BSP** features make non-gated image intensifier tubes simply shut themselves off or, in the worst case scenario: the tube simply burns through, i.e. "dies". As a result an operator cannot see anything for a few seconds: these seconds mean people's safety and lives. Under the same conditions, an auto gated image intensifier will react immediately producing uninterrupted, contrast image, allowing the device to perform and the operator to see the environment in details and respond appropriately.

*ABC=Automatic Brightness Control, BSP=Bright light Source Protection. These are standard features in all currently made Gen. 2+ and Gen. 3 IITs. However, one must understand that neither ABC, BSP nor Auto Gating guarantee 100% protection against exposing of your night vision device to extremely bright or intense light sources, such as a laser or the sun. Such abuse will eventually kill the tube or dramatically reduce its performance.

Conclusion. Auto gating is by far the most effective performance-enhancing feature. It adds a reasonable amount of money to the price of a night vision system. Many people order night vision devices with auto gated tubes for the piece of mind as it delivers great performance and better protects the image intensifier tube —the most expensive component in the device.

Detection, Recognition, Identification (DRI)

Unlike thermal imaging where lighting conditions have literally no effect on a thermal device's performance, having even a miniscule amount of ambient light is vital for operation of a night vision device. For example, if you have a good quality Gen. 3 device with a 1X magnification lens, then at full moon you will be able to detect a vehicle at about 1200m. However if it was an overcast night, detection distance would reduce by a whopping 50%, down to 600m.

As in any case with thermal systems, DRI values are affected by a number of factors that are related to the environment, object, night vision system itself and the operator who uses it. The lists of factors are not exhaustive, other factors may also affect DRI values.

PART III. NIGHT VISION SYSTEMS: DRI

Environment Characteristics

Fog / Haze / Mist
Rain / Snow
External sources of light
Levels of light pollution
Air density
Other climatic obscurities

Night Vision System Characteristics

Tube Generation
FOM Value
Sensitivity
Optical magnification
Objective lens aperture (f-number)

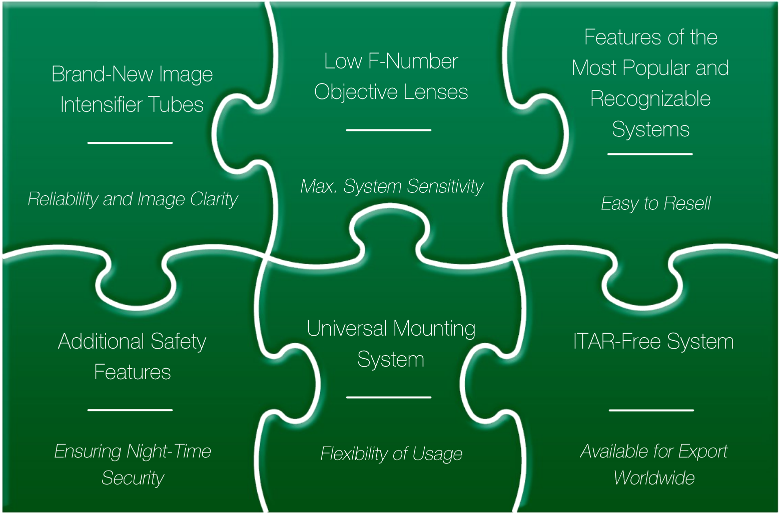
Human Factors

Training
Experience
Expectations for targets
Stress
Concurrent task load
Clarity of vision
Fatigue
Set tube gain level
Optics focusing
Cleanliness of optics
Placement of device

Object Characteristics

Object Size
Camouflage
Object's speed and direction

What Makes a Night Vision Device Great?



Buyer's Checklist

This section of the guide presents what you need to know when buying a night vision or a thermal imaging device.

Keep in mind that a good quality night vision or thermal imaging device is not cheap and for many customers it is a serious investment. It is crucial to clearly understand *what* you are buying before you hand over your money.

Oftentimes the price tag is a defining factor. It is a natural desire of anyone of us to buy the highest performance and quality for the least amount of money. At the same time we all understand that by definition, any good quality product cannot be cheap. *There are no miracles.* Even a small reduction in price can indicate significant shortfalls in reliability, build quality and performance. In many cases, savings *DO NOT* justify compromises on quality and performance. It might sound counterintuitive but it is more economical to purchase a more expensive but higher quality device. In the long run, reliability, performance and pleasure of experience justify the extra money spent.

PART IV. BUYER'S CHECKLIST

On the next few pages we provide a list of "must-ask" questions as well as critical factors that you need to pay attention to.

At the end of the guide we put a blank comparison table for your convenience. When you shop around, ask dealers and/or manufacturers to provide technical data and price for particular devices, write down the results and compare yourself.

GSCI is ready to give you a professional and *unbiased* opinion. You can contact us and discuss your findings even without naming brands or models. Our specialists will advise you as to which product would best fit your needs and budget.

Note: manufacturing of thermal engines and image intensifier tubes requires expensive, technologically advanced production line. There is only a handful of respectable and trusted companies in the world that supply the market with quality FPAs and IITs.

PART IV. BUYER'S CHECKLIST: CHOOSING A NIGHT VISION DEVICE

Ask about the following:
Tube's manufacturer and country of origin
Tube generation and FOM values
Front lens f-number and focal length
Device's country of manufacture
Warranty and export information

Preferred characteristics:
Brand-new tube
Use of standard, easy-to-find batteries
Long warranty period
Made at vendor's facility

Stay away from:
High f-number optics
Military surplus/refurbished tubes
Unusually large DRI values
Re-branded devices

PART IV. BUYER'S CHECKLIST: CHOOSING A THERMAL IMAGING DEVICE

Ask about the following:

- ? FPA sensitivity and front lens f-number
- ? Non-uniformity correction technique
- ? Refresh rate
- ? Housing material (metal, plastic, etc.)
- ? Device's country of manufacture
- ? Warranty and export information

Preferred characteristics:

- ✓ Brand-new FPA with high refresh rate
- ✓ Use of standard, easy-to-find batteries
- ✓ Long warranty period
- ✓ Made at vendor's facility

Stay away from:

- ✗ High f-number optics (f/1.6 and up)
- ✗ Low refresh rate models (9Hz)
- ✗ Unusually large DRI values
- ✗ Re-branded devices

Night Vision Specs	Device 1	Device 2	Device 3
Brand, Model			
IIT Generation (1, 2, 2+, 3)			
FOM			
Autogated (yes/no)			
Manual Gain Control (yes/no)			
Front Lens f-number			
Battery Type and Quantity			
Any Polarity Battery Insertion?			
Country of Origin			
Warranty			
Export Restrictions			
Price			

PART IV. BUYER'S CHECKLIST: COMPARISON TABLES

Night Vision Specs	Device 1	Device 2	Device 3
Brand, Model			
IIT Generation (1, 2, 2+, 3)			
FOM			
Autogated (yes/no)			
Manual Gain Control (yes/no)			
Front Lens f-number			
Battery Type and Quantity			
Any Polarity Battery Insertion?			
Country of Origin			
Warranty			
Export Restrictions			
Price			

PART IV. BUYER'S CHECKLIST: COMPARISON TABLES

Thermal Imaging Specs	Device 1	Device 2	Device 3
Brand, Model			
FPA Resolution			
FPA Sensitivity, mK			
Refresh Rate, Hz			
NUC Technique			
Front Lens f-number			
Battery Type and Quantity			
Battery Life, hours			
Country of Origin			
Warranty			
Export Restrictions			
Price			

Thermal Imaging Specs	Device 1	Device 2	Device 3
Brand, Model			
FPA Resolution			
FPA Sensitivity, mK			
Refresh Rate, Hz			
NUC Technique			
Front Lens f-number			
Battery Type and Quantity			
Battery Life, hours			
Country of Origin			
Warranty			
Export Restrictions			
Price			

NIGHT VISION AND THERMAL SYSTEMS: EXAMPLES

Examples of Night Vision Systems

All Systems Feature:

- New Gen 3 / XR5 / 4G IITs
- f/1.2 optics
- Best-In-Class Battery Life

PVS-14C Night Vision Monocular

- Multi-Functional Design
- Any-Polarity Battery Insertion

PVS-7 Night Vision Goggles

- Popular US Army Model

PVS-31C-MOD Dual-Tube Night Vision Goggles

- True Stereo Vision
- Depth Perception
- Selective Channel Engagement

Examples of Thermal Imaging Systems

All Systems Feature:

- <60mK FPA Sensitivity
- NUC-Less Technology
- 50Hz Refresh Rate
- All-Aluminum Body

UNITEC-G64 Thermal Imaging Goggles

- 640x480 FPA
- 25mm f/1.0 Objective

UNITEC-B50-38 Thermal Imaging Binoculars-Goggles

- 384x288 FPA
- 50mm f/1.0 Objective

WOLFHOUND-64-L4 Thermal Imaging Sight

- 640x480 FPA
- 100mm f/1.4 Objective

ADVANCED DETECTION SOLUTIONS: ULTRA-LONG RANGE DETECTION

Special requirements call for special equipment. For certain applications (border control, marine and others) it is vital to detect a target at a maximum distance possible. This is where ultra-long detection systems come to help. One example of such systems is the TLR-7150 Series.

Thanks to a <50mK sensitivity FPA, a 150mm f/1.0 objective lens and a set of image-enhancing solutions, the TLR-7150 is capable of detecting a vehicle-size target as far away as 20 kilometers (12.5 miles) at any time of the day or night.

LIST OF COMMON ABBREVIATIONS

n	ABC	Automatic Brightness Control
n	AG	Auto Gating
n	BSP	Bright Source Protection
c	DRI	Detection, Recognition, Identification
n	IIT (or I2T)	Image Intensifier Tube
c	ITAR	International Traffic in Arms Regulations
t	FPA	Focal Plane Array
n	FOM	Figure Of Merit
c	FOV	Field Of View
c	MGC	Manual Gain Control
t	NUC	Non-Uniformity Correction
c	OEM	Original Equipment Manufacturer
n	SNR	Signal-to-Noise Ratio

n - term related to night vision
t - term related to thermal imaging
c - common term