APPENDIX E

FORWARD LOOKING INFRARED

The purpose of this appendix is to provide the gunner with a greater understanding of how the Javelin acquires its' target. Visible light is seen either directly from a light source or indirectly as the light reflects from an object into the eye. On the other hand, the Javelin is able to create images using the infrared part of the spectrum in a process referred to as Imaging Infrared or I²R.

E-1. INTRODUCTION

The Javelin allows the gunner to see a target at night and during light rain, fog, haze, or dusty atmospheric conditions by taking advantage of a type of energy similar to visible light, known as "infrared."

E-2. ELECTROMAGNETIC SPECTRUM

The electromagnetic spectrum (Figure E-1) contains various forms of energy including radio and television transmission spectrums, x-rays, and visible light humans can see. Visible light is a very small portion of the overall electromagnetic spectrum. Each type of energy is assigned a place in the spectrum according to its frequency—from lowest to highest. As the frequency changes, the characteristics change, so types of energy are bundled into groups of frequencies, or bands, which have similar characteristics. The Javelin uses the infrared band for its sights (NVS and seeker).

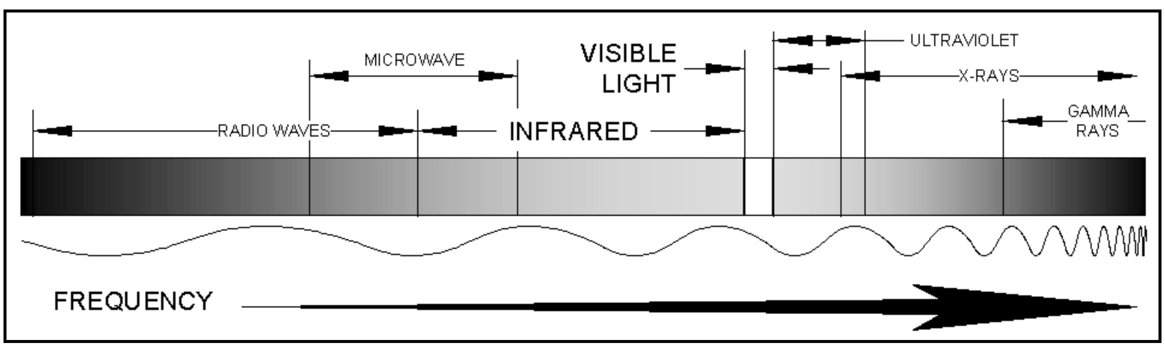


Figure E-1. Electromagnetic spectrum.

a. The Javelin operates, using frequencies in only a small part of the IR band (Figure E-2, page E-2). Other weapon systems operate in this same area, such as the TOW and Dragon, which means the gunner should be able to see anything with the TOW and the Dragon that he can see with the Javelin.

b. Other systems operate using frequencies in other parts of the IR band. This operation includes such equipment as the commander's ground pointer (CGP) and night vision goggles (NVG). Using the CGP and NVGs as an example, when the platoon leader points to a target with the CGP, the gunner can see what the platoon leader points at because the NVGs that the gunner wears operates at the same IR frequency as the CGP.

Using the Javelin, the gunner cannot see where the CGP points because it emits a beam outside the IR band that the Javelin uses.

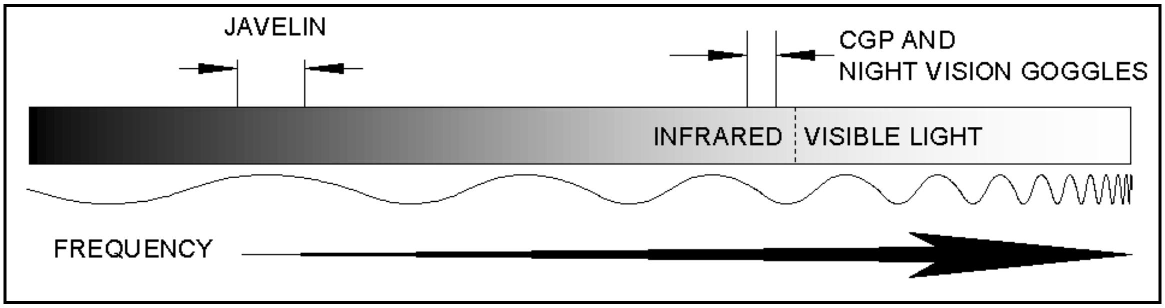


Figure E-2. Infrared band.

E-3. INFRARED WAVES

The IR waves are a ***radiant***, an electromagnetic form of heat. Heat creates IR waves and IR waves create heat. For instance, the heat lamps at fast-food restaurants are above the food, yet they keep the food warm even though heat rises. The reason is that the lamps radiate IR waves down onto the food, and when the IR strikes the food, the food warms up. IR can be emitted in any direction.

a. **Infrared Sources**. Everything on the face of the earth emits IR in the IR band used by the Javelin. Hotter objects emit more IR, and cooler objects emit less. Some objects are classified as IR sources meaning they are able to stay hot by themselves using another form of energy—such as nuclear energy, combustion, and friction—to generate heat energy.

(1) ***Nuclear energy***. Nuclear energy is produced either by splitting atomic particles (called fission) or combining atomic particles together in different forms (called fusion). The sun uses a nuclear reaction to generate heat and is our primary source of IR energy.

(2) ***Combustion*** (Figure E-3). Combustion means there is heat produced by a slow (such as a bonfire) or very quick (such as a controlled explosion) burning. Vehicle engines generate heat due to combustion.

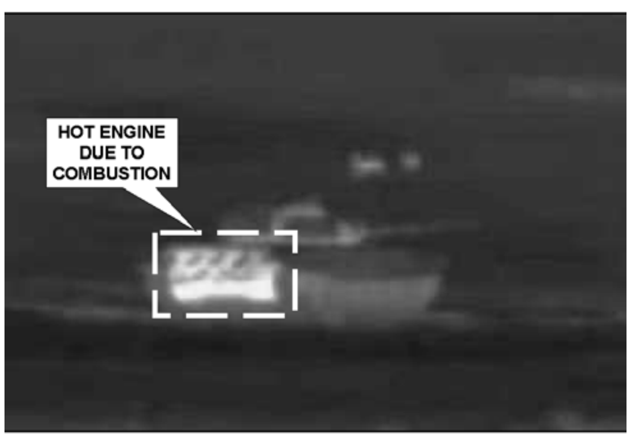


Figure E-3. Heat caused by combustion.

(3) ***Friction***. Friction produces heat by rubbing objects together. For example, when you rub your hands together very quickly, friction causes your hands to warm up, which causes them to give off more IR. The same reaction occurs when a vehicle moves. Its suspension and motion mechanism (tires or tracks) creates friction moving against themselves or against the ground causing the suspension parts to warm up and produce IR (Figure E-4).

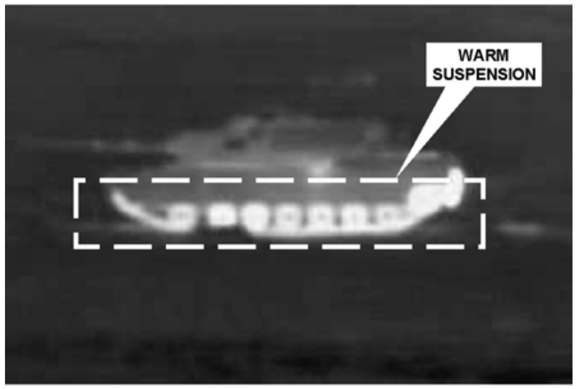


Figure E-4. Heat caused by friction.

b. **Infrared Characteristics**. All objects have the IR characteristics of reflection (if IR energy is reflected as in a mirror), absorption (if IR energy is absorbed as in friction), and emission (if IR energy comes from an IR source as in combustion). Like visible light, IR is affected by being transmitted through the atmosphere.

(1) ***Reflecting versus absorbing***.

(a) All objects reflect and absorb IR energy in varying amounts. What is not absorbed is reflected. Objects that reflect IR well do not absorb it well. Plant life, such as trees and grass, reflects IR well. This reflection makes the plants appear to heat up instantly when the sun strikes them and to cool off instantly when the sun blocks the plants.

(b) Absorbing is the opposite of reflecting. Objects that absorb IR well do not reflect it well. Objects such as tanks and rocks absorb IR well. When the sun comes up, this absorption makes these objects stay cold or cool for a longer time when everything else is warm. When the sun goes down, these objects stay hot much longer than other objects in the target scene. For example, illumination tape that becomes dimmer the longer it glows.

(2) ***Emitting IR***. Emitting is closely associated with absorbing. Just like illumination tape that absorbs light before it glows, objects are heated to emit IR. For example, an emitting source is like a combustion engine that generates heat or the human body. When an object absorbs IR, it warms up. As it warms up, it emits more IR. When the heat source is removed, the object continues to emit IR, which causes it to cool off, and the amount of IR that it emits steadily decreases.

(3) ***Transmitting IR***.

(a) Just like light, IR is affected by particles in the atmosphere known as ***obscurants*** because they obscure the gunner's view of the target scene. Obscurants include such things as dust, snow, hail, sleet, fog, and so forth. The effect these obscurants have on IR is noticeably less than their effect on light. Unlike light, some obscurants have no effect on the ability to see an IR image

(b) Obscurants with large-sized particles—snow, sleet, rain, fog, and some forms of smoke—affect the amount of IR that reaches the NVS. As these obscurants become thicker or heavier, the amount of IR that reaches the NVS decreases, which decreases the range at which a gunner can see a target with the NVS.

c. **Physical Properties**. When the sun comes up, some objects heat up faster than others do because they have different IR characteristics. An object's IR characteristics are determined by its physical properties—its mass, density, color, and texture. These properties combine to enhance an object's ability to reflect or absorb the IR that comes into contact with it.

(1) ***Color***. Light colored objects, such as a vehicle with desert camouflage, reflect more IR than they absorb, and heat slowly in the sun (Figure E-5). Dark colored objects, such as a vehicle with woodland camouflage, absorb more IR than they reflect, and heat quickly in the sun.

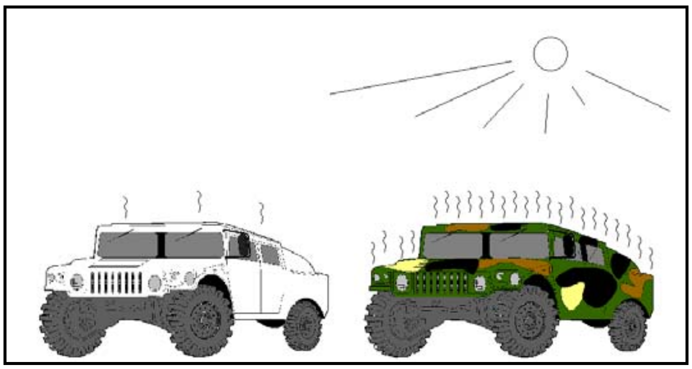


Figure E-5. Infrared affected by color.

(2) ***Density***.

(a) When objects such as trees and grass are exposed to sunlight, they do not become too hot to touch because they do not absorb IR well. As a result, they do not emit IR well, either. The reason is because the material they are made of is not very dense or heavy.

(b) When objects such as vehicles and rocks are exposed to sunlight, they can become too hot to touch because they absorb and emit IR well. The reason is because these objects are denser or heavier than the trees and grass.

(3) ***Surface texture***. Although a military HMMWV and the civilian version (Hummer) both become hot when exposed to sunlight, the Hummer does not heat up as fast as the HMMWV does. The reason for this is the difference in the surface texture, or finish, on the two vehicles. The Hummer has a smooth, waxed surface which tends to reflect well, whereas the HMMWV has a rough surface due to the chemical-agent resistant coating (CARC) paint that tends to absorb well (Figure E-6).

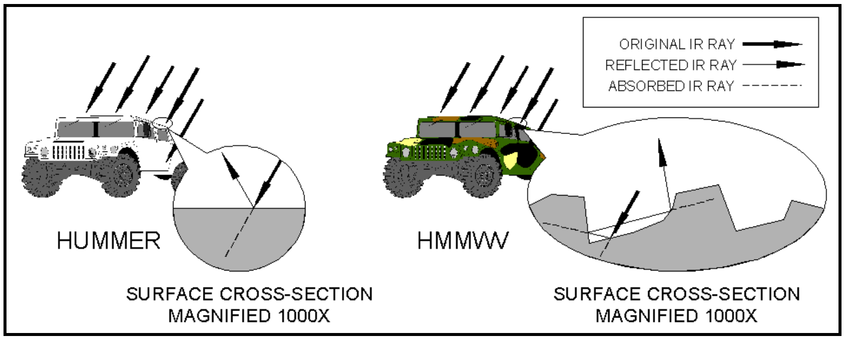


Figure E-6. Smooth versus rough surface texture.

(4) ***Mass***.

(a) The more mass an object has, the more IR it can absorb, the longer it takes to heat up, the longer it can emit IR, and the longer it takes to cool off.

(b) When both a tank and an M16 are in the sun, the armor plates on the tank take longer to heat up than the barrel of the M16 because they have more mass. As a result, the armor plates absorb more IR, and they take longer to heat up to the same temperature as the M16 barrel. Once they are hot, the armor plates emit IR for a much longer time than the barrel of the M16 and they take longer to cool off.

E-4. INFRARED SYSTEMS

There are two types of IR systems: nonimaging and imaging.

a. **Nonimaging Systems**. Nonimaging systems, such as the Stinger surface-to-air missile, are known as ***heat seekers***. Heat seekers do not provide an IR image of the target.

b. **Imaging Systems**. The imaging systems convert IR into a visible-light image. The Javelin is an imaging system providing an IR image that can be used to engage a target. When the missile is launched, it uses a similar image to guide it to the target.

E-5. DELTA-T

The NVS and seeker use IR to create images regardless of visible light levels. The images they display are made possible by the presence of Delta-T's (ΔT's). ΔT's allow us to distinguish between one part of the target scene and another—whether it is different parts of the same object or different objects in the target scene. The gunner can use the Javelin's IR imagery during the day as well as at night.

a. **Definition**. ΔT is an abbreviation for ***change in temperature*** or ***difference in temperature***. Delta (Δ) is a Greek letter that stands for ***change*** or ***difference***. ***T*** stands for temperature.

b. **Temperature/Infrared Relationship**. As the temperature of an object increases, so does the amount of IR it emits. For example, the engine compartment on a tank with its engine running emits more IR than the front of the hull.

c. **Display of Infrared Levels**. The NVS and seeker display IR levels as a change in brightness, according to each object's temperature. The coldest objects in a target scene appear black; the hottest appear bright green. Everything in between appears as increasingly brighter shades of green as each object's temperature increases.

For example, the engine compartment on a tank with its engine running appears bright green (Figure E-7). Since the hull generally is the coldest part of a tank, it appears black. The suspension, which is hotter than the hull but cooler than the engine compartment, appears in a different shade of green.

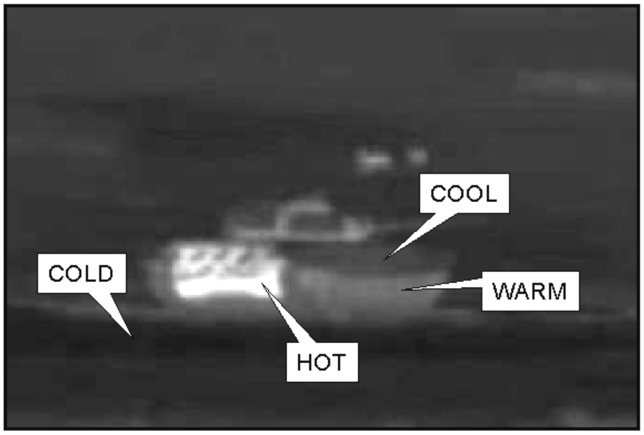


Figure E-7. Display of IR levels.

NOTE: In the figures shown, the coldest objects appear black and the hottest appear white (bright green in the CLU). Everything in between appears as increasingly brighter shades of gray (shades of green in the CLU).

d. **ΔT to Visible Image**.

ΔT's occur between different objects in the target scene and between the different parts of a target. This technique allows the gunner to see different objects in the target scene, and to distinguish between different parts of a target (Figure E-8). For the gunner to see a target with the Javelin, a measurable ΔT which, for Javelin, is a difference between objects of 1 degree Fahrenheit or greater must exist between the target and its background (Figure E-9).

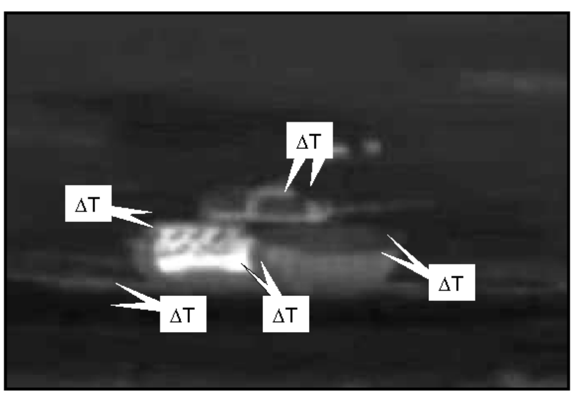


Figure E-8. Delta-T's.

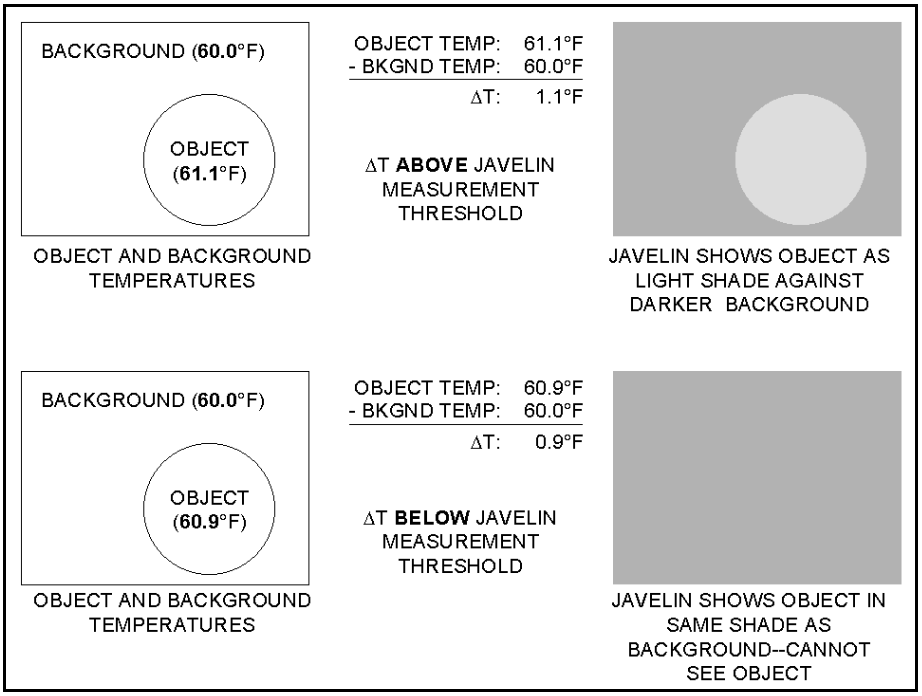


Figure E-9. Measurable Delta-T.

e. **ΔT's Over a 24-Hour Period**.

(1) The temperature relationship between one object and another changes during the day due to heating and cooling as the sun rises and sets.

(2) The gunner knows that vehicles, buildings, and asphalt roads get hot in the sun. Grass and trees become warm but not so hot they cannot be touched. Large bodies of water do not warm up noticeably in one day. Objects that heat up the most during the day tend to become the coldest at night. Objects that heat up very little during the day tend to cool off very little at night (Figure E-10). To illustrate, two images are seen on the same terrain (one at noon and the other at midnight).

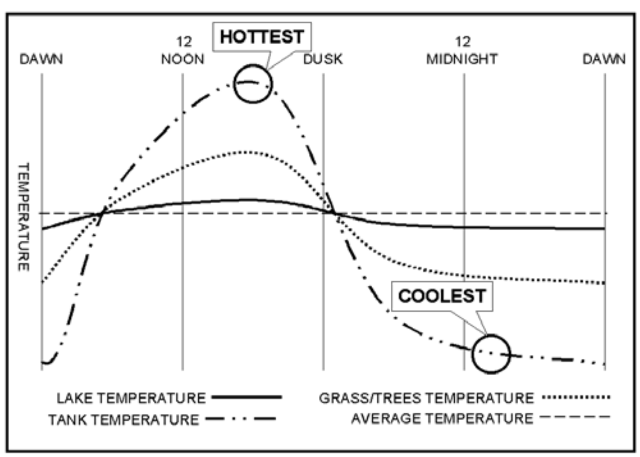


Figure E-10. Temperatures of objects during 24-hour period.

(a) In the noon example (Figure E-11A), notice the buildings, roads, and vehicles are the hottest objects in the scene. The grassy areas and trees are shaded to indicate they are warm, and the river is black, which indicates it is the coolest object in the target scene.

(b) In the midnight example (Figure E-11B), notice how the ΔT's changed. Now, the river is the warmest, the grass and trees are next, with the roads and vehicles being the coolest, with the exception of the engine compartment and exhaust on the vehicles. This example shows how the relationship of ΔT's changes among objects in a target scene over the course of a day.

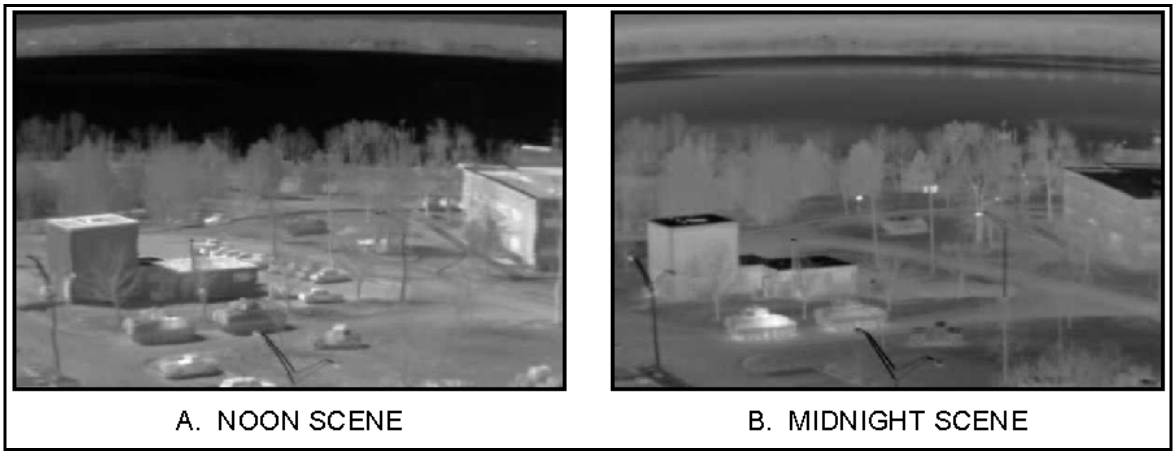


Figure E-11. ΔT changes from day to night.

(3) **Infrared Cross Over.** Twice a day, around dawn and dusk, the temperatures of the tank, grass, and trees cross over from being hotter than the river to being cooler (Figure E-12). These two periods are known as *IR cross over* because of the change in the temperature relationships and the visual effect that it produces. During these two periods, everything in the target scene is about the same temperature, which means there are few, if any measurable ΔT's. As shown earlier, when there is no measurable ΔT, the gunner cannot distinguish a target from its background.

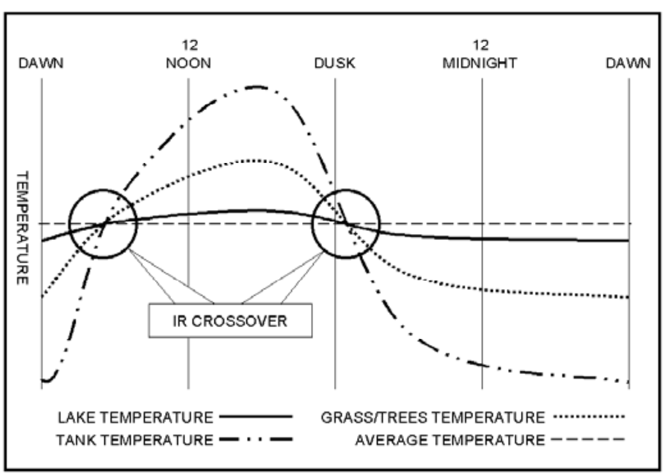


Figure E-12. Crossover periods.

f. **Infrared Image Adjustment**. Proper image adjustment is vital to accomplish the mission because it allows the gunner to see targets that may otherwise be hidden. There is no *perfect* image adjustment. Image adjustment is subjective and should be done according to what the gunner prefers.

(1) ***Focus***. The FOCUS switch adjusts NVS image focus. (An object is in focus when the gunner can easily identify its details or features.) Just like a camera, when an object is in focus in the NVS, anything closer or further away appears out of focus. When the gunner first uses the NVS after cool down, he adjusts the focus before he adjusts the contrast and brightness. Otherwise, the edges of objects in the target scene are blurred, and the gunner is not able to adjust contrast and brightness properly (Figure E-13).

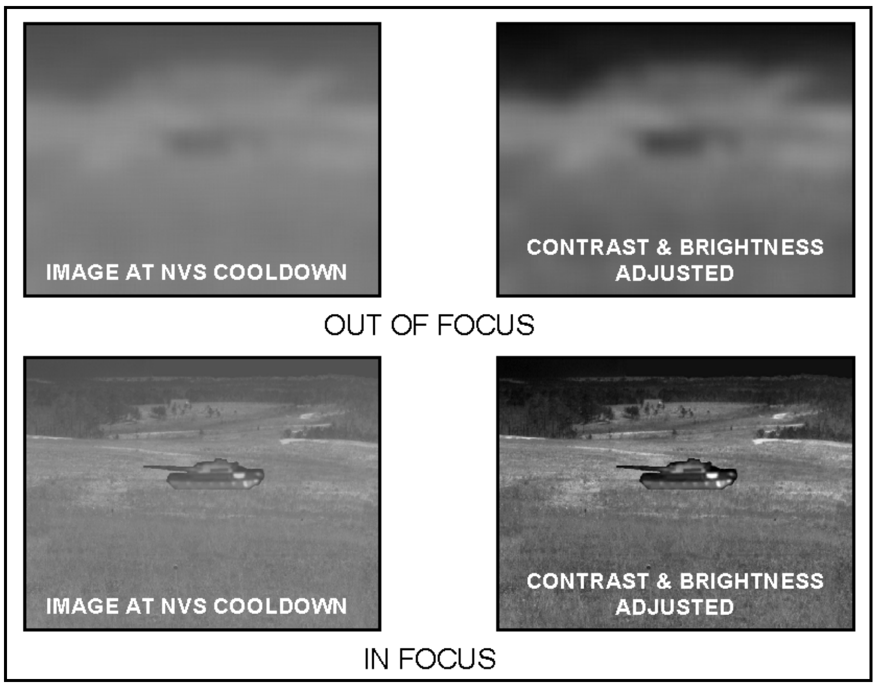


Figure E-13. Focus adjustments.

NOTE: Before focusing the NVS image, focus the CLU display with the diopter adjust ring.

(a) *Initial adjustment*. To adjust focus initially:

- Pick an object in the target scene, such as a far tree line.
- Press the FOCUS switch in either direction until the tree line is in focus (Figure E-14, page E-10).

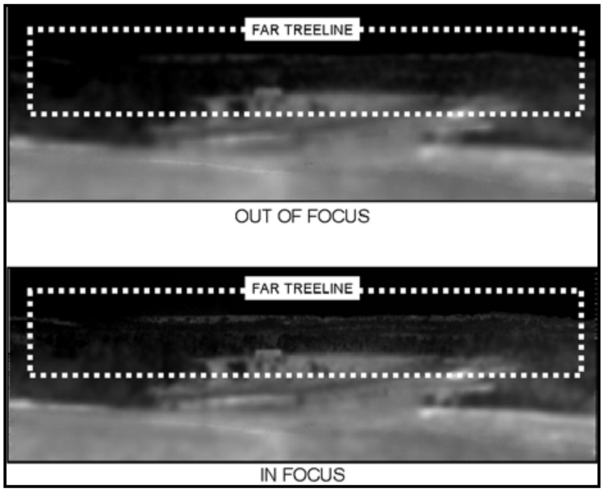


Figure E-14. Focus on far tree line.

- If the tree line becomes more blurred, release the FOCUS switch and press it in the other direction.

NOTE: If adjusting the focus to either limit, the applicable FOV indicator (WFOV or NFOV) flashes to indicate the NVS is at a focus limit. Release the FOCUS switch and adjust it in the other direction.

- When the tree line comes into focus, release the FOCUS switch. If the focus adjustment overshoots, press the FOCUS switch back and forth to make minor adjustments.

(b) *Adjustment speed*. The NVS focus adjustment has two speeds available (press and release or press and hold).

- Minor adjustments. When the gunner presses and releases the focus switch in either direction, the focus adjusts at slow speed (Figure E-15). This procedure allows for fine tuning the focus for a specific object.

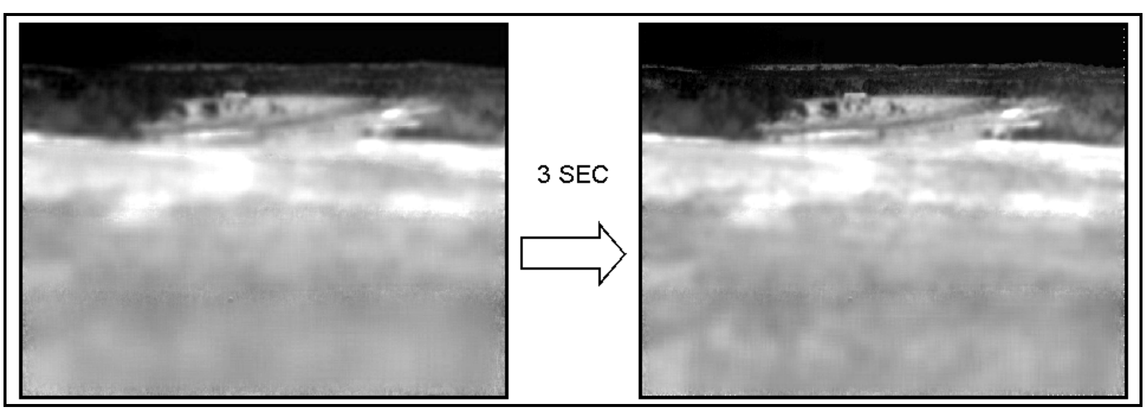


Figure E-15. Slow focus adjustment.

- Major adjustments. When the gunner presses and holds the FOCUS switch in one direction, the focus adjusts at a slow speed for the first three seconds. After that, focus automatically changes to high speed until the gunner either releases the switch or reaches a focus limit (Figure E-16). The high adjustment speed lets him focus quickly on another object that is much closer or much farther away.

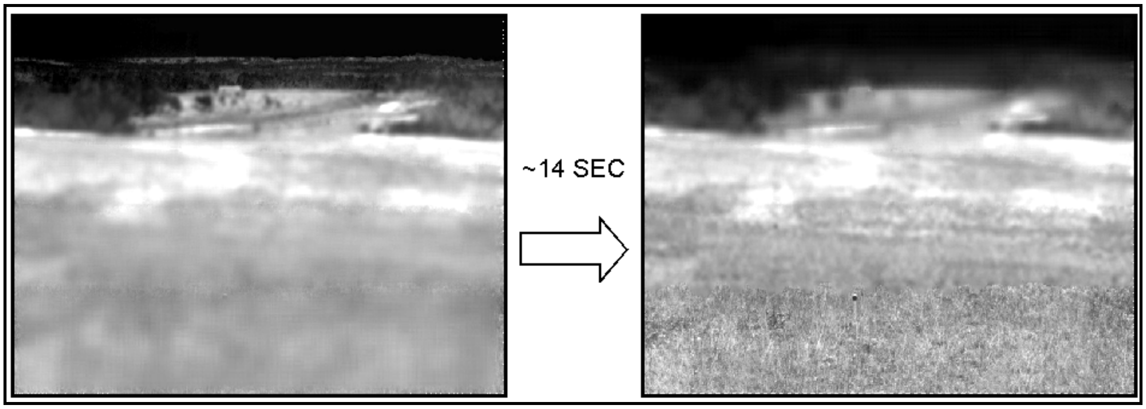


Figure E-16. Fast focus adjustment.

(c) *Focus direction*. To focus on objects farther away, press the FOCUS switch up (Figure E-17). To focus on objects that are near, press the FOCUS switch down.

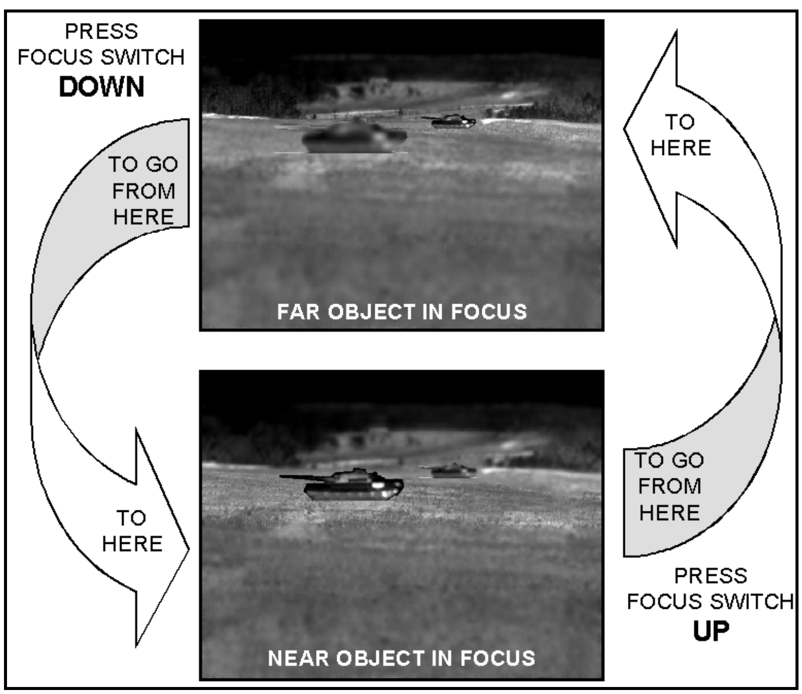


Figure E-17. Focus direction.

(2) ***Contrast and Brightness Adjustment***. Once the image is in focus, it may be necessary to adjust the contrast and the brightness. As the situation changes, the gunner adjusts the focus, the contrast, and the brightness to help in target acquisition.

(a) *CLU power-up*.

- When the power switch is turned to NIGHT and the NVS reaches cool down, the NVS automatically adjusts contrast and brightness for the IR in the target scene (Figure E-18). This gives the gunner a baseline image for making an initial focus adjustment only. He still needs to fine tune the contrast and brightness according to the task.

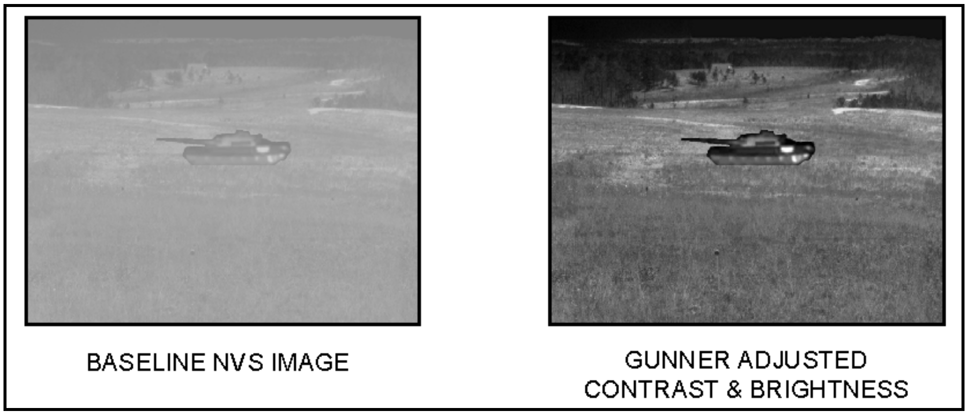


Figure E-18. NVS initial contrast and brightness baseline.

- Contrast and brightness. The gunner adjusts the contrast and the brightness to an extreme (all black or all bright green) and cannot readjust to obtain a usable image.
- Corrective action. The gunner takes corrective action by turning the power switch to DAY, then back to NIGHT. The NVS adjusts itself to the baseline image (Figure E-19).

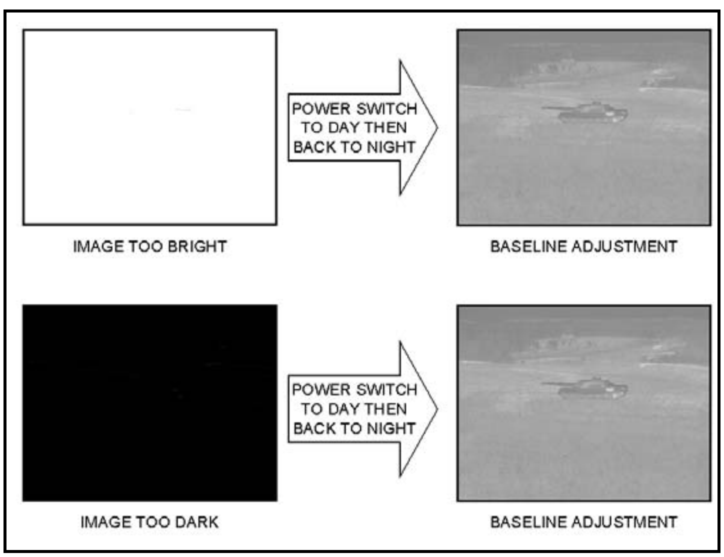


Figure E-19. Return to baseline from an extreme contrast/brightness adjustment.

(b) *Good adjustment*. A properly adjusted target image is one in which the gunner sees a few black spots (the coldest objects) and a few bright green spots (the hottest objects) (Figure E-20). Everything else should be distributed across the shades of green.

- Adjusting the brightness affects the contrast, and adjusting the contrast affects the brightness. The gunner adjusts one, then the other, in small increments, until he has a target image that looks good to him for the task he is doing.
- If the gunner cannot tell whether to adjust the contrast or the brightness first because the entire screen appears bright green or the entire screen appears black, he adjusts the brightness first. If the gunner can see everything in the target scene, he adjusts the contrast first.

Figure E-20. Properly adjusted contrast and brightness.

(c) *Contrast adjustment*. Contrast adjusts the difference between the bright green objects and the black objects with respect to the middle shades of green.

NOTE: In this manual, bright green objects in the CLU appear white in the figures used here. Objects that are shades of green in the CLU appear in shades of gray in the figures.

- Contrast too high (Figure E-21, page E-14). When contrast is too high, all objects are adjusted away from the shades of green in the middle toward the two extremes, so they appear either bright green or black.
- Corrective action. The gunner takes corrective action by decreasing the contrast by moving the GATE ADJ/CTRS & BRT switch left. This decrease brings objects back from the two extremes into the shades of green.

Figure E-21. High versus good contrast adjustments.

- Contrast too low (Figure E-22). When contrast is too low, all objects are adjusted into the shades of green in the middle away from the two extremes, so nothing appears black or bright green.
- Corrective action. The gunner takes corrective action by increasing the contrast by moving the GATE ADJ/CTRS & BRT switch right. This increase spreads the objects out from the middle shades of green back toward the extremes of bright green and black.

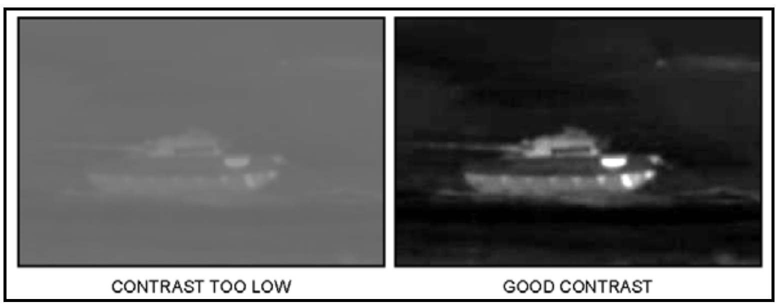


Figure E-22. Low versus good contrast adjustments.

(d) *Brightness adjustment*. Adjusting the brightness changes the intensity, or brightness, of the objects in a target scene in the same direction. Increasing brightness makes all objects brighter, and decreasing it makes them darker.

- Brightness too high (Figure E-23). When the brightness is too high, almost all objects in the target scene appear bright green, a few appear in shades of green, and none are black.
- Corrective action. The gunner takes corrective action by decreasing the brightness by moving the GATE ADJ/CTRS & BRT switch down. This decrease drives down the intensity of all objects until some of them appear black.

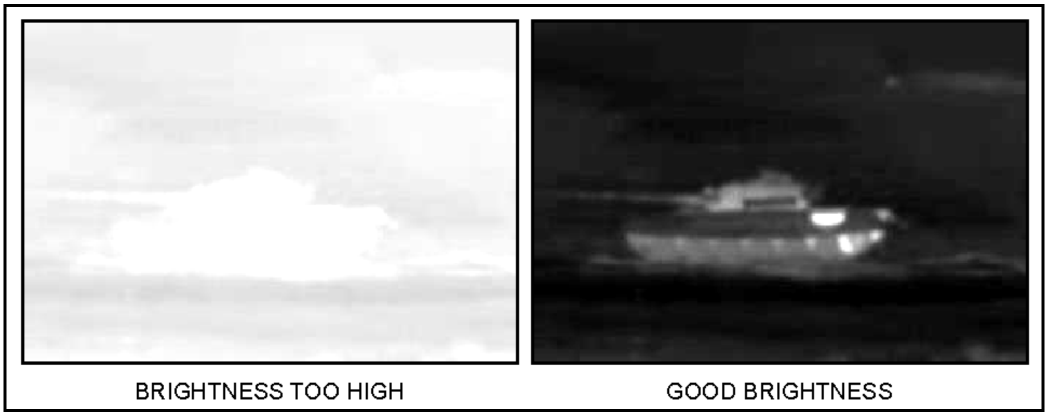


Figure E-23. High versus good brightness adjustments.

- Brightness too low (Figure E-24). When brightness is too low, almost all objects appear black, a few appear as shades of green, and none appear bright green.
- Corrective action. The gunner takes corrective action by increasing the brightness by moving the GATE ADJ/CTRS & BRT switch up. This increase drives up the intensity of all objects until some areas appear bright green.

Figure E-24. Low versus good contrast adjustments.

E-6. FACTORS THAT AFFECT INFRARED TARGET IMAGES AND ΔT's

Conditions that affect the gunner's ability to acquire a target include limited visibility conditions, solar heating, human activity, and range to the target.

a. **Limited Visibility Conditions (Natural and Man-Made)**.

(1) Rain, snow, sleet, fog, haze, smoke, dust, and darkness are referred to collectively as limited visibility conditions. These conditions affect the gunner's ability to acquire and engage targets with the Javelin especially when using day FOV (Figure E-25, page E-16). The gunner uses the NVS to overcome darkness, haze, and some smoke systems.

(2) The NVS can see through low levels of these obscurants better than the daysight. Its capability is restricted at higher levels of obscurations (Figure E-25). The effect on the NVS image is a decrease in contrast.

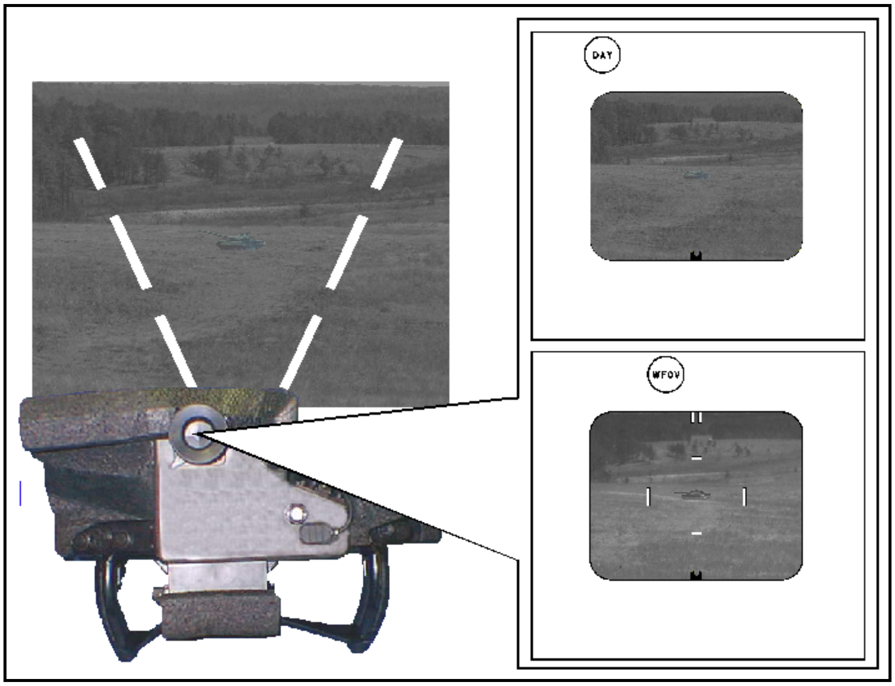


Figure E-25. Day FOV versus NVS operationonduring High levels of obscuration.

b. **Solar Heating**. Solar heating is the single greatest influence on the target scene ΔT changes. Solar heating also causes IR clutter and IR crossover, both of which can restrict the gunner's ability to engage a target.

(1) ***Weather***. Weather can greatly change the amount of solar heat on objects. Objects observed during clear weather have good ΔT's due to the high amount of solar heating. In addition, the objects can change their appearance during a 24-hour period. During periods of precipitation (snow, rain, sleet, and so forth), there is little solar heating and the ΔT's are low.

(2) ***Infrared Clutter***. IR clutter is a term used to describe a pattern of ΔT's in the target scene that prevents the gunner from distinguishing a target from its background. This pattern is similar to the effect that is attempted when a soldier wears the battle-dress uniform (BDU). The reason BDUs have a certain color pattern is the BDU pattern blends with the background, cluttering the gunner's outline and making it difficult for an enemy to see him.

(a) IR clutter can be natural or man-made, and there are several differences between the two including cause or origin, effect on the target scene, area of coverage, time and location of appearance, and temperature of the clutter objects relative to the target.

(b) The sun creates natural IR clutter, which generally covers large areas of terrain, such as a field, scattered rocks, or a hillside, which is a disadvantage when trying to engage a target. (This clutter can prevent the gunner from seeing a target and its movement with the NVS, but not with the daysight.) Natural clutter is unpredictable, so the gunner cannot tell if or when the target is visible. The gunner needs to pay attention to areas of clutter so he can keep track of moving targets that enter these areas. Natural clutter is caused either by solar heating or by IR reflecting off objects in the target scene.

- Clutter from solar heating. When solar heating causes clutter, the clutter stays in the same place and keeps the same appearance for a long time. ΔT's are present in the target and in the background, but the two ΔT patterns match so closely that the gunner may not be able to distinguish the target from the background (Figure E-26). In addition, the range of temperatures in the clutter is the same as those in the target.
- Corrective action. The gunner can first adjust the contrast and the brightness. He may find that contrast and brightness adjustments do not bring out the target from its background. In that case, the gunner must wait for the target to move out of the clutter or wait for the ΔT's to change.

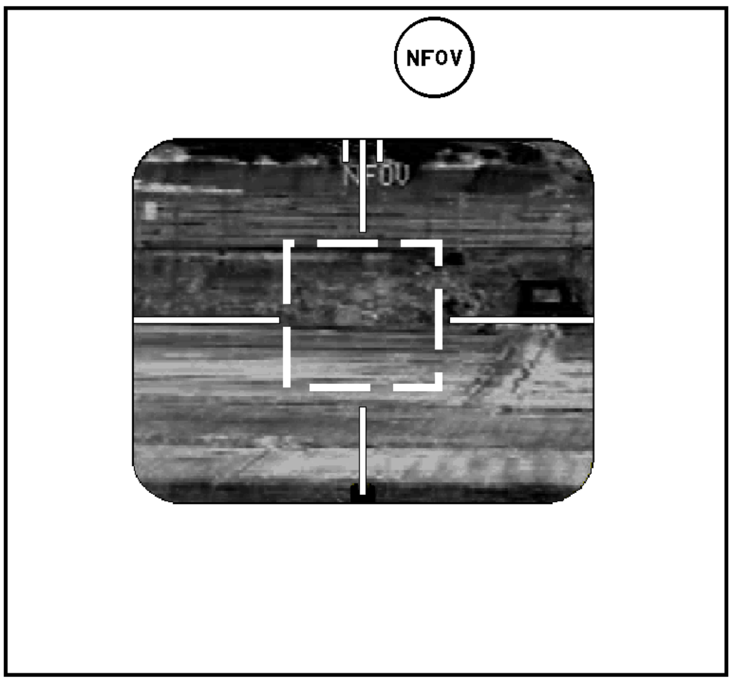
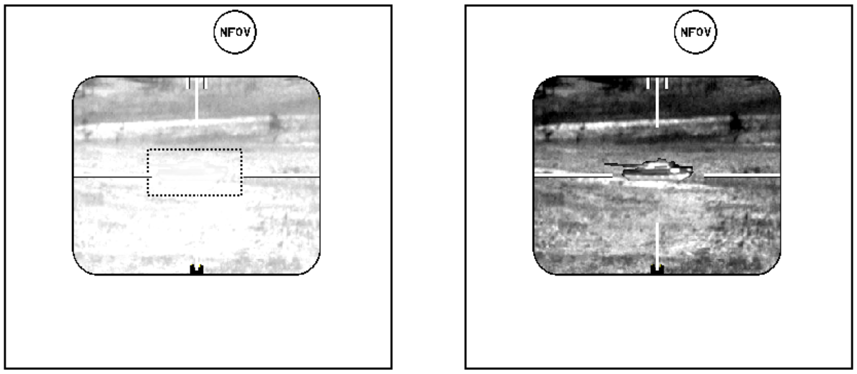


Figure E-26. Infrared clutter—background ΔT pattern matches target ΔT pattern.

- Clutter from reflected IR. When reflected IR causes IR clutter, the clutter comes and goes randomly with the appearance of the sun, and at different locations. (This can cause the gunner to suddenly lose a target that was visible or make a target appear suddenly that was hidden from him.) Its appearance is such that the target and the clutter look like one large area of uniform temperature (Figure E-27, page E-18).
- Corrective action. Generally, a gunner can defeat this type of clutter by increasing the contrast and decreasing the brightness. If not, he must wait for the target to move out of the clutter or wait for the ΔT's to change.



TARGET IN CLUTTER CAUSED BY REFLECTED IR

DECREASE BRIGHTNESS AND INCREASE CONTRAST TO BRING OUT TARGET IMAGE

Figure E-27. Defeating clutter caused by reflected IR.

- Although natural IR clutter can prevent the gunner from seeing the target, it usually occurs during the day when the daysight sight works well for surveillance. However, if he cannot see the target with the NVS, the gunner will not be able to see it with the seeker either.
- Man-made infrared clutter. Man-made clutter is when conditions exist that are influenced by human activity that affects objects in the target scene. When the target is in the area that has flames (burning vehicles or buildings), this can work for the gunner and, at the same time, against him. The enemy vehicle may be able to use the flames to hide, thus making it difficult for the seeker to obtain a lock on. However, based on the ΔT's, the gunner may be able to detect the target (Figure E-28).
- Corrective action. The gunner must change the contrast and brightness based on the appearance of the target. The gunner should start by adjusting the brightness first (Figure E-29), then the contrast (Figure E-30, page E-20). The gunner does this until he has a good target scene. Although the gunner may be able to counter the effects of IR clutter in the NVS (WFOV or NFOV) by adjusting the contrast and brightness, he may not be able to see the target in seeker FOV. If the corrective action does not work the target scene and allow the gunner to acquire the target, he should do the following:
  —Wait for the target to leave the area of IR clutter.
  —Wait for the target to change in temperature, then try to engage the target.
  —Wait for the objects causing the IR clutter to change in temperature, then try to engage the target.

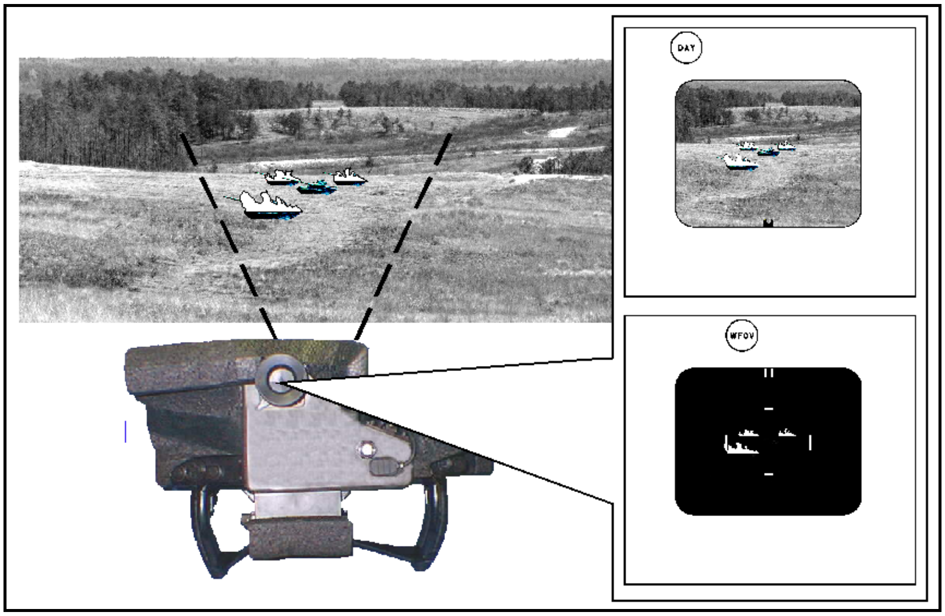


Figure E-28. Effects of man-made clutter on NVS target scene.

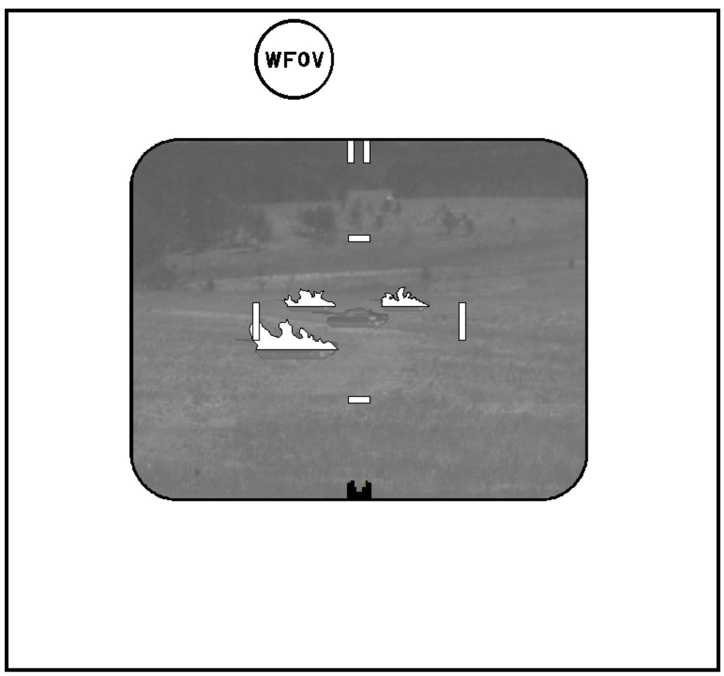


Figure E-29. Counteracting man-made clutter Step 1—adjust brightness.

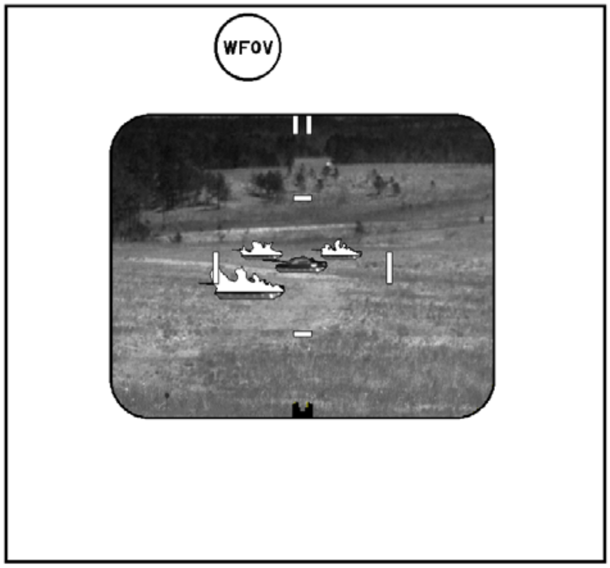


Figure E-30. Counteracting man-made clutter Step 2—adjust contrast.

- Infrared crossover. IR crossover prevents the gunner from seeing the target because everything in the target scene (the background terrain and the target) is about the same temperature. This occurs twice in a 24-hour period at dawn and again at dusk. During this time, the target is nearly the same temperature as its background, so the ΔT between the target and its background is low (Figures E-31). The Javelin detects ΔT's as low as 1-degree Fahrenheit.

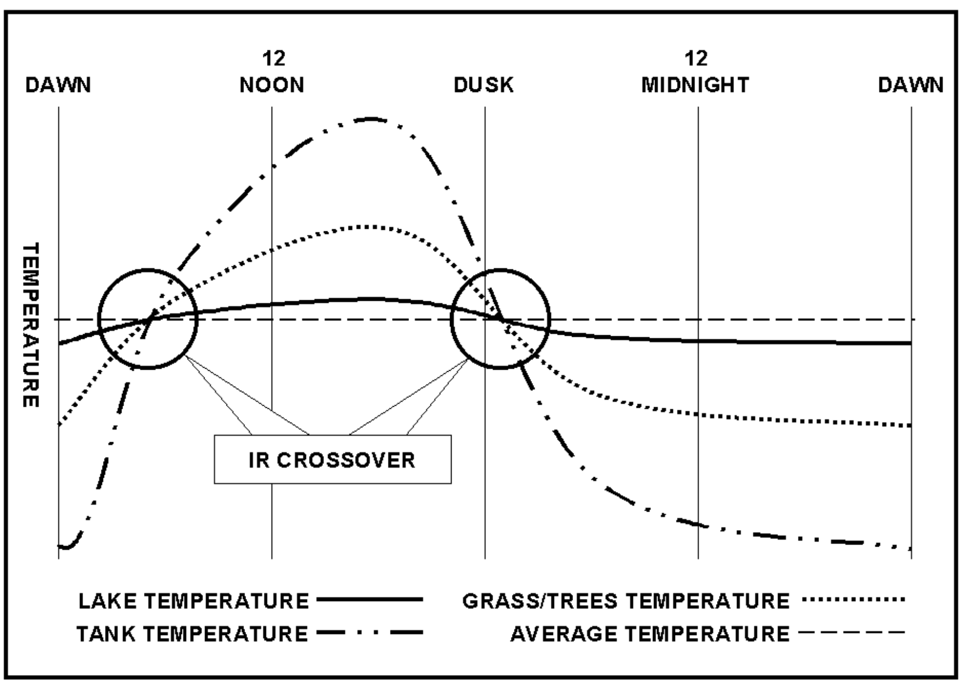


Figure E-31. IR crossover times.

- Corrective action. The gunner can use this capability to overcome the effects of crossover by adjusting contrast and brightness. In addition, crossover will not occur for all parts of the target at the same time. Part of the target will always have a measurable ΔT between it and the background so the gunner can determine the target's location (Figure E-32).

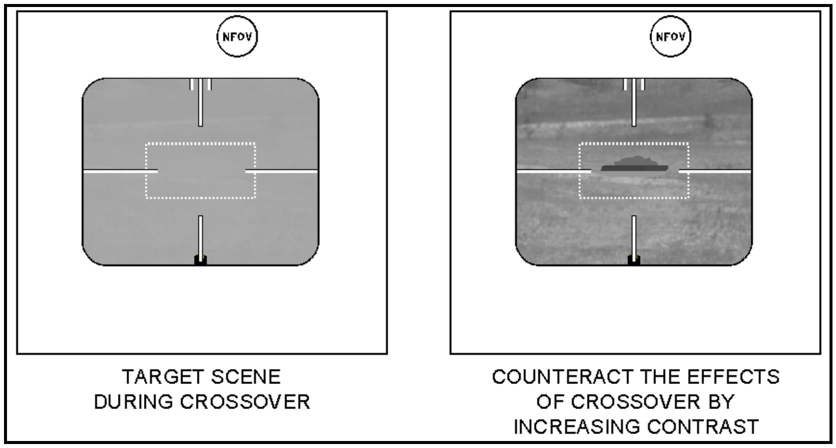


Figure E-32. Infrared crossover effects.

- Human activity. Human activity has an effect on the amount of IR in objects in the target scene, which disrupts the natural changes that should occur in their IR images. For example, at night, vehicles and asphalt roads should appear dark green. When a vehicle is driven for a while, it appears bright green around the engine, exhaust, and suspension as a direct result of human activity. When enough vehicles drive on a road, it will appear as light green where wheel or track friction causes the road surface temperature to increase (Figure E-33).

Figure E-33. Road temperature increases due to friction from vehicle tracks.

- Range to target. The gunner's ability to distinguish a target at maximum range from its background is restricted due to limitations of the NVS magnification, image resolution, and obscurants. When the target moves toward the gunner, the clarity of target details increases as range to the target decreases (Figure E-34).

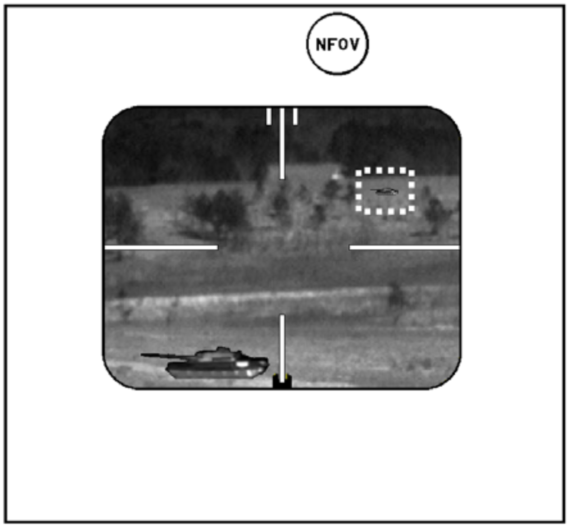


Figure E-34. Effects of range on target details.

E-7. TARGET ACQUISITION

Target acquisition consists of target detection, classification, recognition, and identification, (Figure E-35). Each step has a specific FOV associated with it. These FOV steps allow the gunner to progress efficiently into target engagement. The first three steps are discussed in the target acquisition process only. Target identification is taught at the unit level. Various media is available to assist the unit in this training.

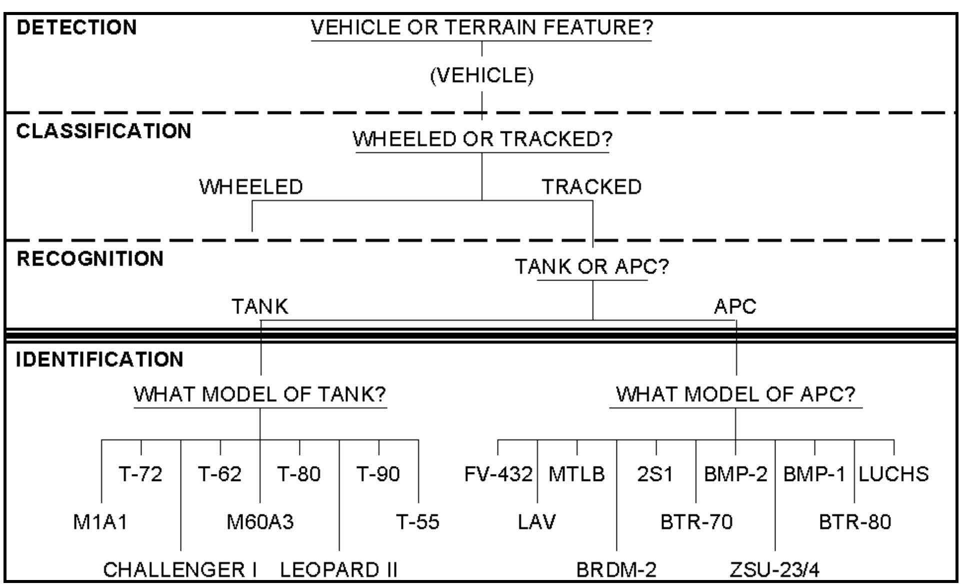


Figure E-35. Target acquisition steps.

a. **Field-of-View Sequence**. As the gunner detects, classifies, and recognizes a target, then, determines its engageability, he must change the FOV, as the task requires. The FOV sequence is day FOV, WFOV, NFOV, and seeker FOV (Figure E-36).

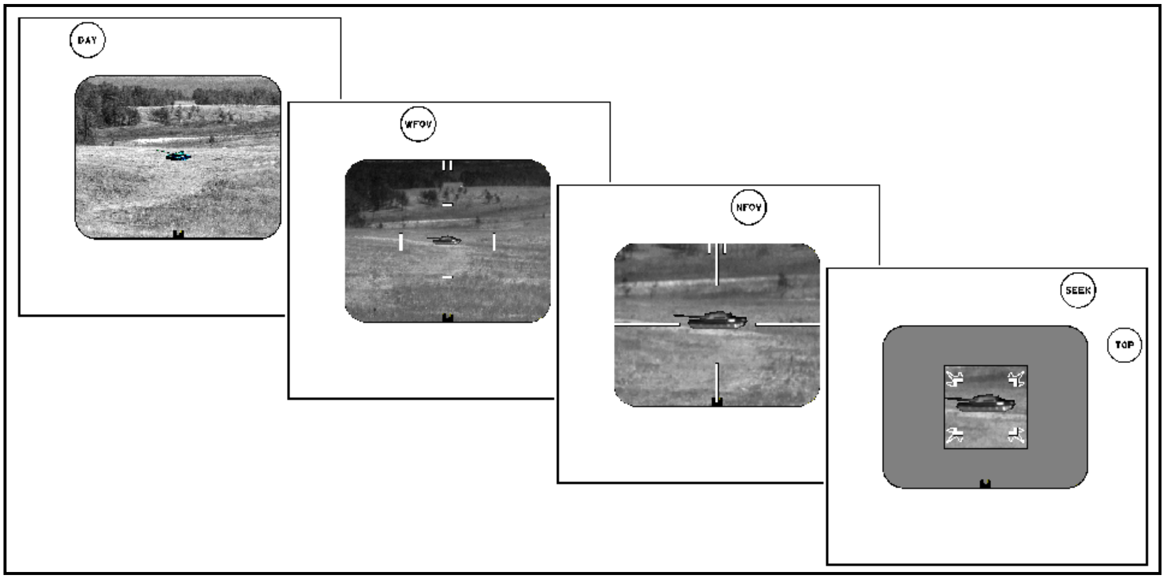


Figure E-36. Target engagement FOV sequence.

(1) ***Day Field-of-View***. Day FOV provides a full-color, visible-light target image with 4x magnification (Figure E-37). Day FOV imagery is only useful during daylight hours with clear weather. The gunner should use it primarily during NVS cool down or when the IR conditions make it difficult for him to see the target in the NVS. Day FOV covers a large area and is used primarily for surveillance and target detection. The 4x magnification limits the gunner's ability to make out target details that are required for target classification, recognition, and identification. However, the gunner may activate the seeker in this FOV to perform a quick engagement.

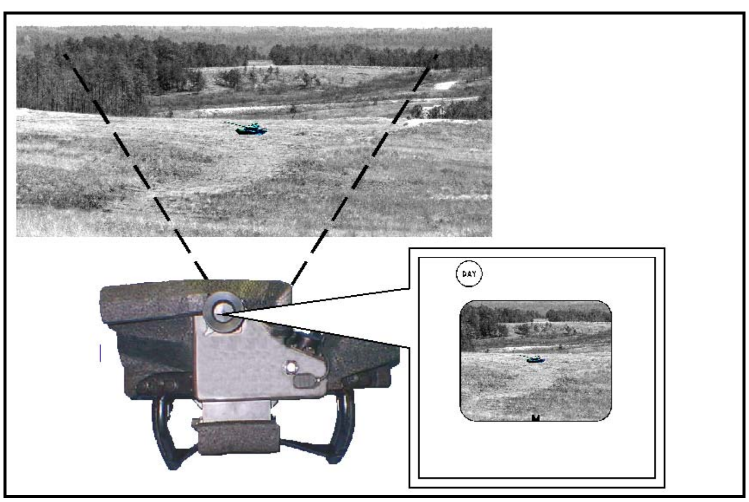


Figure E-37. Day field-of-view image and area of coverage.

(2) ***Night Vision Sight***. The NVS provides two fields of view: WFOV and NFOV. Both provide IR images and can be used at any time of day under any weather conditions. The NVS is the gunner's primary sight.

(a) *Wide field-of-view*. WFOV provides 4.2x magnification of the target scene (Figure E-38). WFOV is ideal for use during surveillance and target detection due to its large area of coverage. The low magnification means the gunner cannot see the target details very well, which makes it a poor tool for target classification, recognition, and identification.

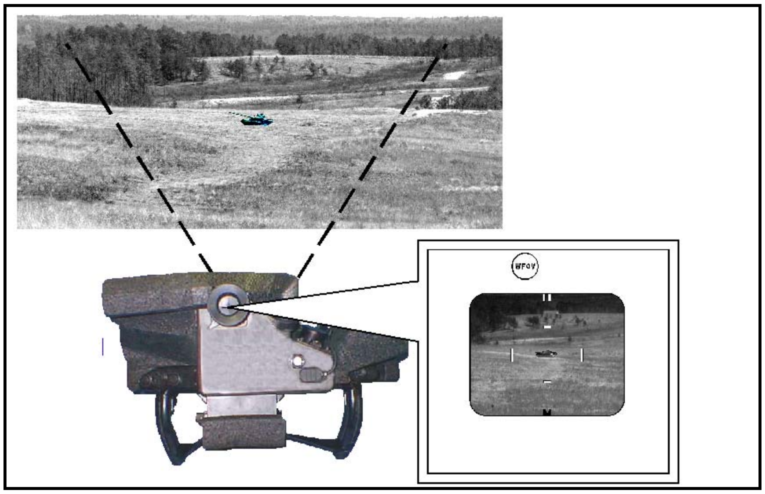


Figure E-38. Wide field-of-view image and area of coverage.

(b) *Narrow field-of-view*. NFOV provides about 9x magnification of the target scene (Figure E-39). Its higher magnification means that NFOV is useful for seeing target details for target classification, recognition, and identification. At the same time, the restricted area of coverage makes it difficult to use for target detection.

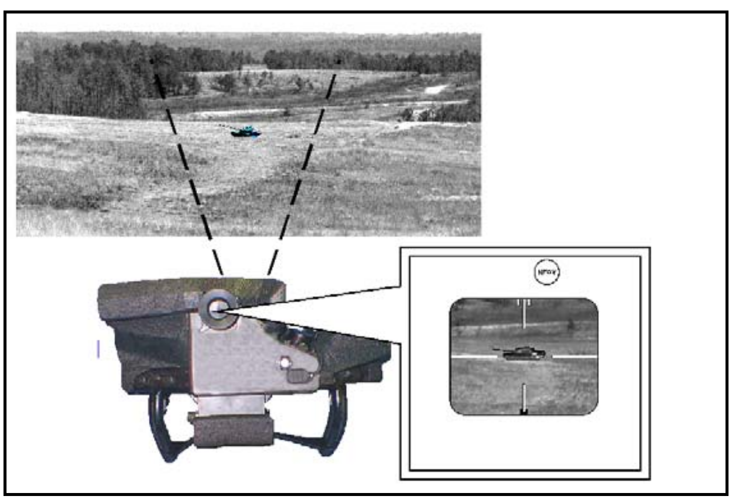


Figure E-39. Narrow field-of-view image and area of coverage.

(3) ***Seeker Field-of-View***. Seeker FOV provides an IR image with about 9x magnification (Figure E-40). The seeker FOV has a limited coverage area and image resolution, and should be used only for engaging targets

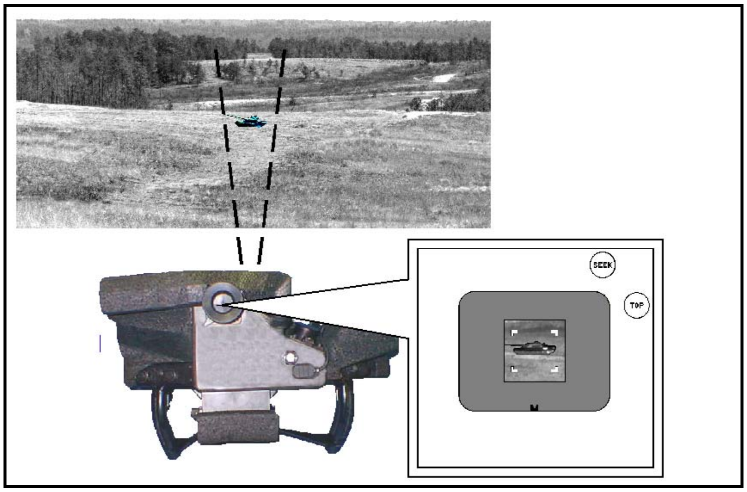


Figure E-40. Seeker field-of-view image and area of coverage.

b. **Target Detection**. The first step in the target acquisition process is target detection (Figure E-41). During this step, the gunner scans his sector of fire to find or acquire a target using the CLU, mainly the NVS. Some techniques that help detect targets are discussed below.

DETECTION VEHICLE OR TERRAIN FEATURE?

(VEHICLE)

Figure E-41. Target acquisition—detection.

(1) ***Definition***. Target detection describes the process by which the gunner visually locates and distinguishes the features of a vehicle from the surrounding terrain features.

(2) ***Scanning for Targets***. The gunner should—

(a) Scan the entire sector of fire using WFOV.

(b) Scan slowly and steadily in a consistent, systematic pattern.

(c) Pay special attention to those positions in which a target might appear.

(d) Identify the location of objects, such as TRPs, trees, roads, buildings, and previously killed targets that have a distinct IR signature. This procedure enables the gunner to quickly locate targets in his sector of fire.

(e) Look for man-made shapes that have straight lines and block angles.

(3) ***Scanning Techniques***. The gunner must scan his sector of fire at all times for the enemy using rapid scan, slow scan, and detailed search.

(a) *Rapid scan*. (See Figure E-42.) Used to detect obvious signs of enemy activity. It is usually the first method the gunner uses. To conduct a rapid scan, do the following:

- Search a strip of terrain about 100 meters deep, from left-to-right, pausing at short intervals.
- Search another 100-meter strip farther out, from right-to-left, overlapping the first strip scanned, pausing at short intervals.
- Continue this method until the entire sector of fire has been searched.

(b) *Slow scan*. The slow scan search technique uses the same process as the rapid scan but much more deliberately, which means a slower side to side movement and more frequent pauses. When a possible target has been detected, stop and search the immediate area thoroughly using the detailed search.

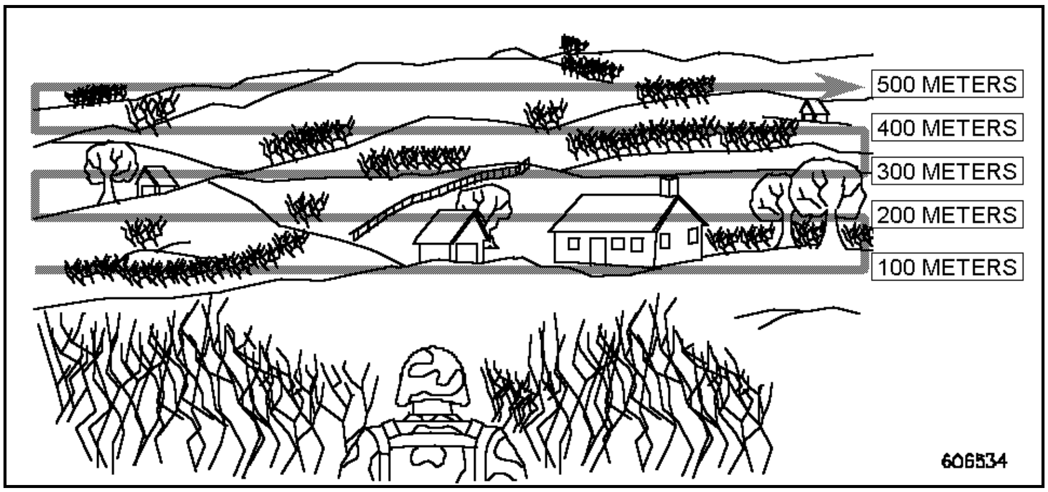


Figure E-42. Rapid/slow scan pattern.

(c) *Detailed search*. If the gunner finds no targets using either the rapid or slow scan techniques, he makes a careful, detailed search of the target area using NFOV (Figure E-43). The detailed search is like the slow scan, but searching smaller areas with frequent pauses and almost incremental movement. The detailed search, even more than the rapid or slow scan, depends on breaking a larger sector into smaller sectors to ensure everything is covered in detail and no possible enemy positions are overlooked.

- Concentrate on likely vehicle positions and suspected armor avenues of approach.
- Look for target signatures around prominent terrain features, such as road junctions, hills, and lone buildings. Also, look at areas with cover and concealment, such as tree lines and draws.

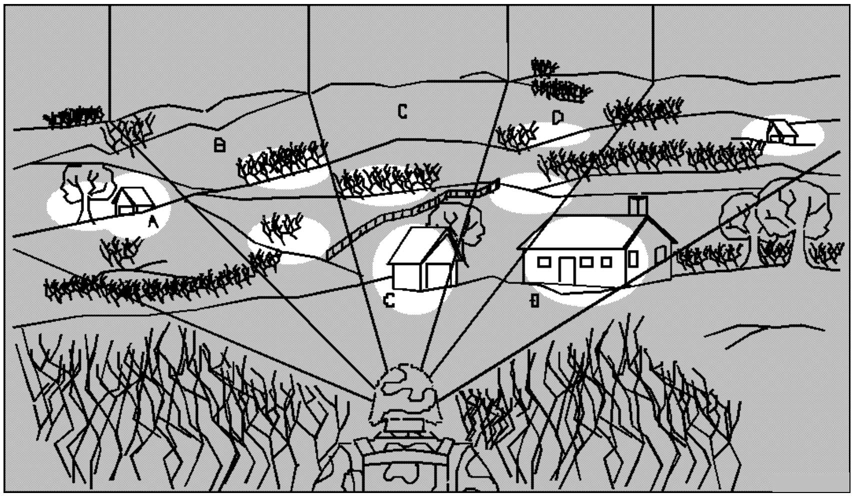


Figure E-43. Detailed search.

c. **Defensive Operations (Moving Targets)**. When trying to detect the enemy, the gunner should look and listen for signs of enemy presence:

(1) ***Dust or Vehicle Exhaust***. Moving vehicles often raise dust. Stay alert for dust because it can be spotted at long ranges (Figure E-44).

Figure E-44. Dust cloud from moving vehicle.

(2) ***Vehicle Movement***. Look for enemy movement along high-speed avenues of approach. Search along terrain features that offer masking, such as tree lines and draws.

(3) ***Flashing Hot Spots***. As a vehicle moves over small gullies and hills at a distance, its hot spots appear to be flashing and appear to become visible, then invisible as the vehicle drops below the observation line.

(4) ***Sounds***. Equipment or vehicle sounds can alert the gunner to the direction or general location of the enemy. These sounds may not pinpoint the enemy's exact location, but if a sound alerts the gunner to a general area, he is more likely to spot the enemy in that area using the detailed search technique.

(5) ***Image Adjustment***. The gunner can spot moving targets easily due to the hot IR signatures from the suspension, engine compartment, and exhaust, and due to the changes in the target aspect as the target moves in his sector of fire. When the gunner is in a defensive position, he adjusts the image so he can see all of the terrain features (Figure E-45). This procedure helps him locate any targets moving in his sector of fire.

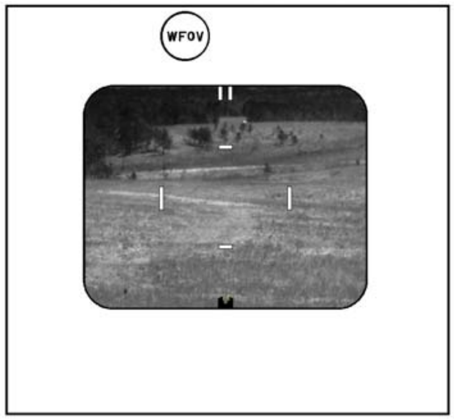
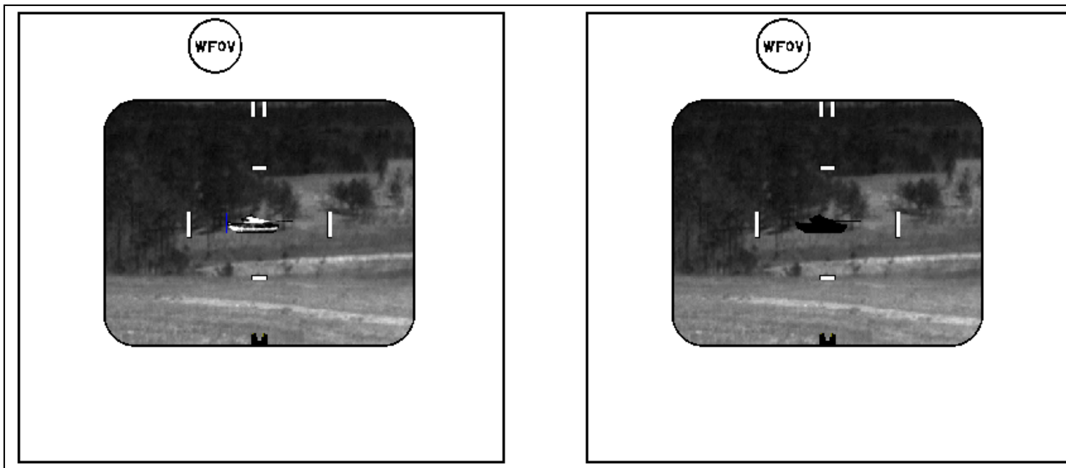


Figure E-45. Image adjustment for defensive position.

d. **Offensive Operations (Stationary Targets)**. During offensive operations, the gunner may encounter stationary targets. A stationary target is more difficult to detect than a moving target, because it does not give away its location by moving, but can be partly or completely concealed by a terrain feature. Key IR signatures may be cold. Depending on how long the target has been stationary, the gunner may see hot, cold, or partly cool signatures. The IR image of a hot, stationary target is much easier to detect than that of a cold, stationary target (Figure E-46). The gunner can augment his visual search to find an enemy emplacement. The difficulty in detecting a target is directly affected by the temperature of the surrounding terrain.



HOT STATIONARY TARGET COLD STATIONARY TARGET

Figure E-46. Hot and cold stationary targets.

(1) ***Sounds***. Listen for equipment and vehicle sounds.

(2) ***Vehicle Exhaust***. Be alert to the presence of vehicle exhaust. Tanks need their engines started every few hours to charge the batteries, which creates a large plume of exhaust (Figure E-47) and a distinctive smell, which may linger even after the engine has been turned off.

Figure E-47. Vehicle exhaust.

(3) ***Dismounted Troops*** (Figure E-48). The human body is a good IR source, and appears as a hot image. Watch for dismounted troop movement that can give away the position of a mechanized force.

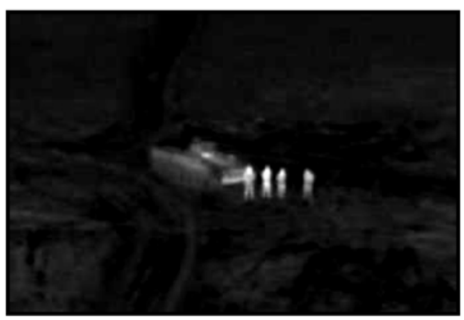


Figure E-48. Dismounted troops as IR source.

(4) ***Vehicle Positions***. Look for enemy positions in obvious places, such as road junctions, hilltops, and lone buildings. Observe areas with cover and concealment, such as wood lines and draws.

(5) ***Image adjustment***. The gunner may have to adjust the image several times to detect stationary targets due to various circumstances and examine the following:

- In what aspect (frontal or flank) the gunner sees the targets, which affects what IR signatures he is able to see.
- If the targets are partly hidden by a terrain feature, such as when it is in defilade or in a tree line.

- Whether targets are hot from recent activity or solar heating, partly cool due to reduced activity, or cold due to long inactivity.

e. **Hot Stationary Targets**. Hot stationary targets are the easiest to detect. When a stationary target has hot signatures, the gunner can assume there has been recent activity or solar heating. To find hot signatures easily, adjust contrast up and brightness down so that only the hottest signatures appear in the FOV, and the rest of the scene is black (Figure E-49). When the gunner thinks he has detected a target, he adjusts the contrast and brightness so he can see the rest of the target's features. Depending on the target's exposure and aspect, some of the signatures to look for include the suspension system, engine compartment/exhaust, gun tube or barrel, and an indirect signature called backlighting.

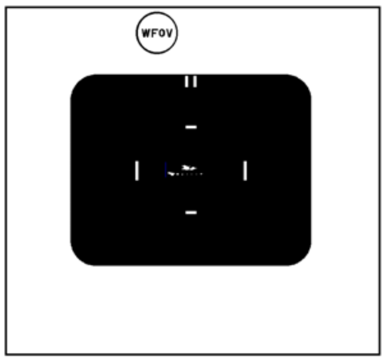


Figure E-49. Image adjustment for detecting hot stationary targets.

(1) ***Suspension System***. When a target has moved recently, its suspension presents a hot IR signature.

(a) The track area presents hot spots due to heating from friction.

(b) When viewed from the front, the tracks are normally visible as two IR signatures on either side of and below a larger dark area (the hull) (Figure E-50). If viewed from the flank, the tracks and road wheels normally are visible as a hot signature beneath a larger dark area (the hull).

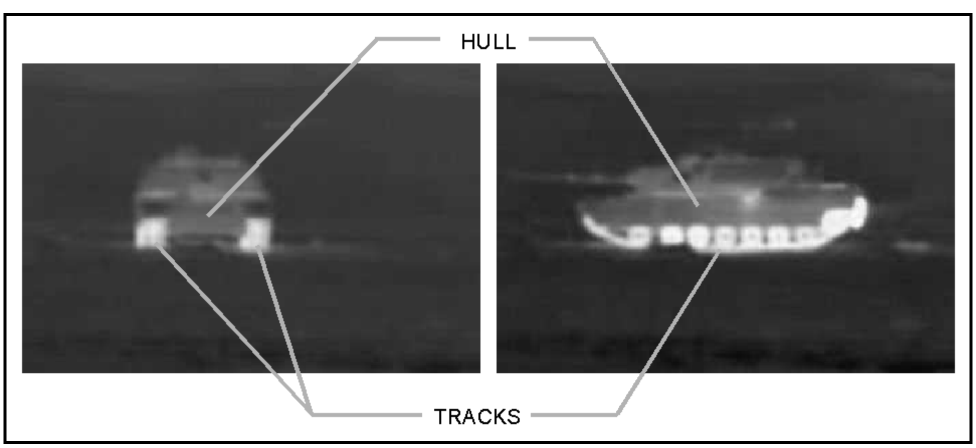


Figure E-50. Track and hull signatures.

(2) ***Engine Compartment*** (E-51). The engine compartment is usually a reliable IR signature for the following reasons:

(a) Due to the extreme heat generated by the engine and the large mass of metal of which it is made, a stationary vehicle's engine compartment gives off a hot IR signature for several hours after the vehicle is stopped. The engine takes longer to cool than the rest of the hull.

(b) A stationary vehicle engine must be started after long periods of inactivity to keep its battery charged. This situation keeps the IR image hot.

(3) ***Gun Tube/Barrel***. The gun tube or barrel is another area to look for heat (Figure E-51). When the gun has been fired recently, it appears hotter than its background.

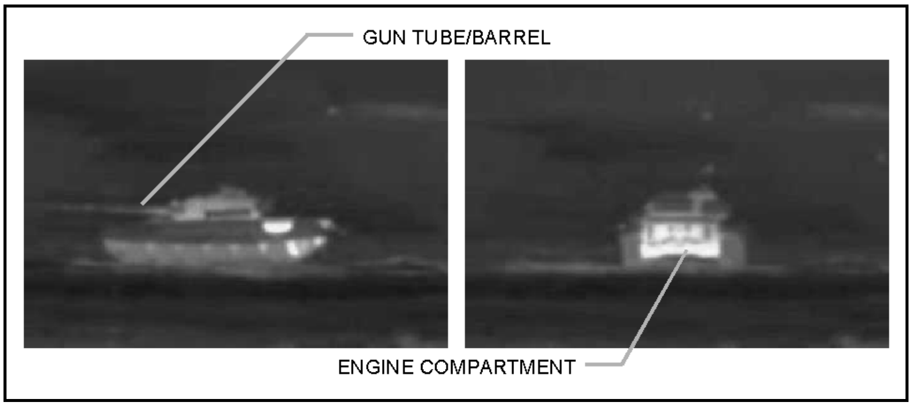


Figure E-51. Engine compartment and gun tube/barrel.

(4) ***Backlighting***. Backlighting is an indirect IR signature that indicates the presence of a target. It is called an *indirect IR signature* because, though it is not physically part of the target, it is caused by heat from the target—usually, from the exhaust. Backlighting occurs when an IR source, such as a tank's exhaust, emits IR, which reflects off another object, such as a tree. Even though the gunner may not see a vehicle, backlighting warns him of its presence (Figure E-52A). When the target is between the gunner and the backlighting, the target may appear as a silhouette (Figure E-52B, page E-32).

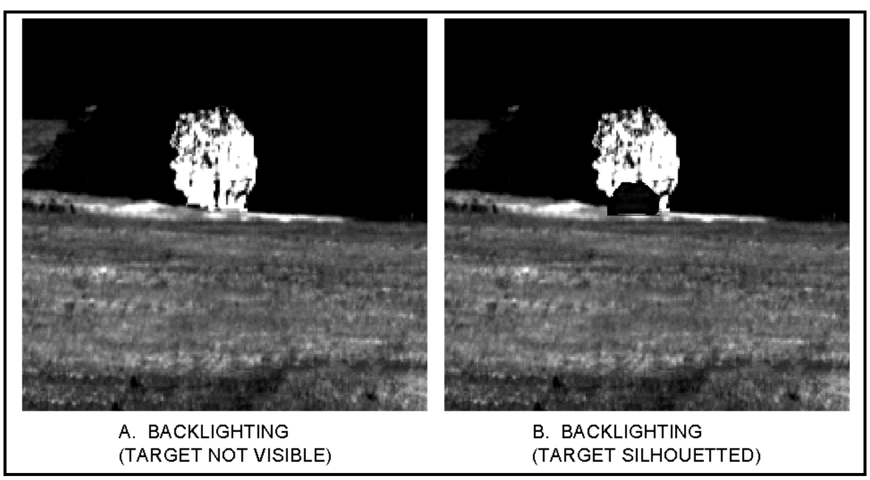
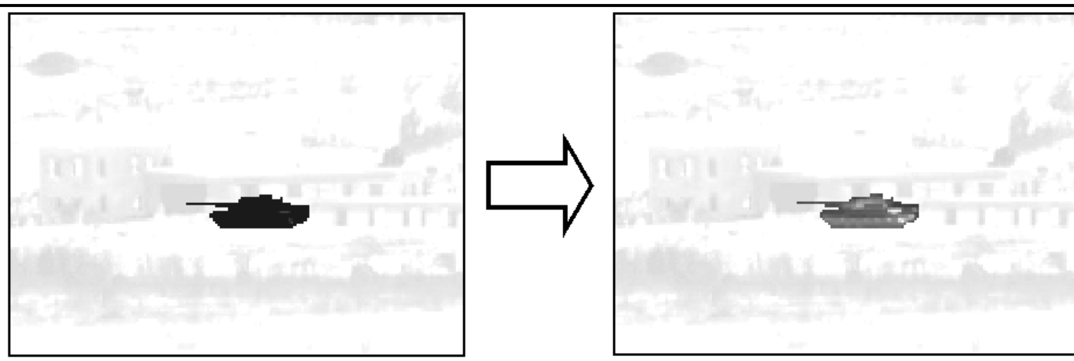


Figure E-52. Backlighting.

f. **Cold Stationary Targets**. When the gunner sees a cold stationary target, he can assume there has been no recent activity. A cold target is cooler than its background. It appears as a dark green or black image against a lighter green background. Look for an IR signature that resembles a silhouette of a wheeled or tracked vehicle (Figure E-53).

(1) To find cold targets easily, adjust contrast up and brightness up so only the coldest signatures appear in the gunner's FOV and the rest of the scene is bright green.

(2) When the gunner thinks he has detected a target, he adjusts the contrast and the brightness so he can see the rest of the target's features.



CONTRAST & BRIGHTNESS ADJUSTMENT TO SEE COLDEST SIGNATURES ON TERRAIN

ADJUST CONTRAST & BRIGHTNESS TO SEE INTERNAL TARGET FEATURES

Figure E-53. Image adjustment for detecting cold, stationary targets.

g. **Partially Cool Stationary Targets**. When stationary targets are partially cooled, the gunner can assume there has been some activity. Partially cool stationary targets are especially difficult to detect because their signatures are closer to the same temperature as the surrounding terrain. Their signatures also become distorted and incomplete as they cool. This procedure causes the signatures to blend with the background. To find partially cool targets, the gunner has to adjust the contrast and the brightness in various combinations while he scans his sector of fire.

h. **Hull Defilade Targets (Tanks)**. Hull defilade targets are the most difficult to detect because they are not visible at all times. When a tank is in defilade, it moves back-and-forth between a firing platform and its hide position.

(1) ***Firing Platform Position*** (Figure E-54A). The tank stays on the firing platform long enough to fire its main gun. During the short period of time that it is in this position, the gunner sees only the turret and gun tube. As soon as the tank fires, it moves to its hide position.

(2) ***Hide Position*** (Figure E-54B). When a tank is in its hide position, the gunner cannot see the target, but he may be able to see the tank commander's head.

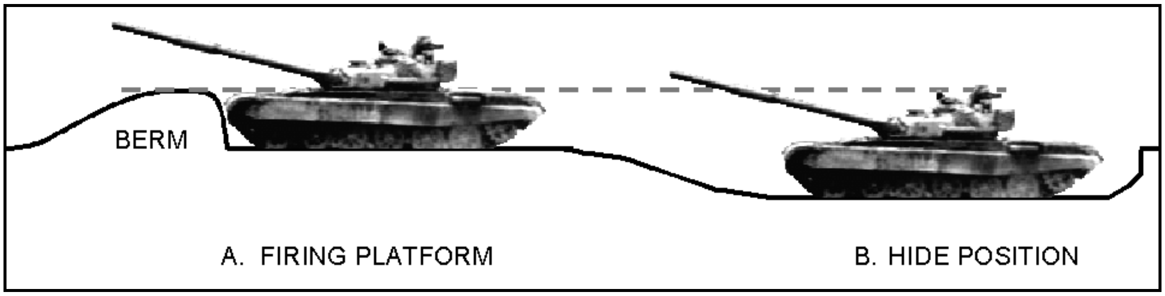


Figure E-54. Tank in defilade.

E-8. TARGET CLASSIFICATION

Once the gunner detects a potential target, he begins the process of elimination to determine the target's classification (Figure E-55).

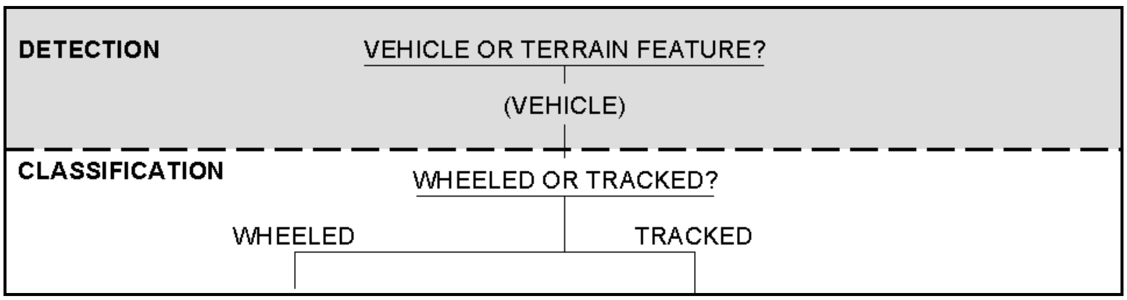


Figure E-55. Target acquisition process—classification step.

a. **Classification Features**. There are specific features that the gunner looks for to classify a vehicle. These features include the suspension system, location of the engine compartment, and presence of a gun tube. Whether or not a feature is visible depends on the target aspect (frontal or flank).

(1) ***Suspension System***. The suspension type defines the target's classification.

(a) *Wheeled vehicle (flank)*. A wheeled vehicle has two- to five-round hot spots at its base that appear large compared to the rest of the vehicle (Figure E-56A, page E-34).

(b) *Tracked vehicle (flank)*. A tracked vehicle has five- to seven-round hot spots created by the road wheels that look small compared to the rest of the vehicle. The tracks may be visible, and depending on the vehicle configuration, the gunner may see return rollers or skirts (Figure E-56A).

(c) *Wheeled and tracked vehicles (frontal)*. On frontal targets, the suspensions for wheeled and tracked vehicles look similar in the NVS (Figure E-56B, page E-34).

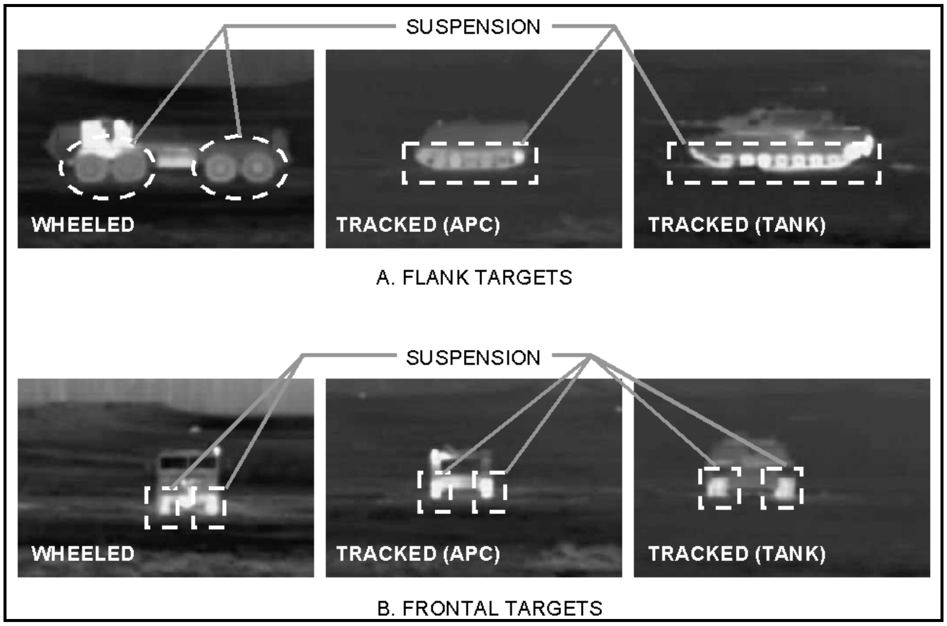


Figure E-56. Classification features—suspension system.

(2) ***Engine Compartment*** (Figure E-57).

(a) *Wheeled vehicles*. Generally, the engine on a wheeled vehicle is located at the front.

(b) *Tracked vehicles*. The location of the engine on a tracked vehicle depends on whether the vehicle is a tank or an APC. Tanks have engine compartments located at the rear. APC's generally have engine compartments located at the front.

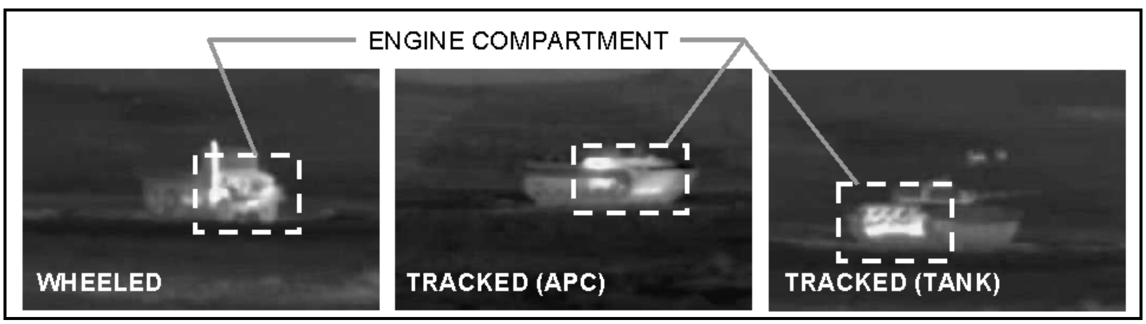


Figure E-57. Classification features—engine compartment location.

(3) ***Gun Tube/Barrel***. When a gun tube or barrel is mounted on a turret or cupola, the Javelin gunner may or may not be able to see it, depending on turret orientation.

(a) *Wheeled vehicle*. In most cases, wheeled vehicles do not have a gun tube, but they may have some type of smaller support gun (machine gun) mounted.

(b) *Tracked vehicle*. When the turret is oriented to the proper angle, the gun tube signature stands out from the turret (Figure E-58).

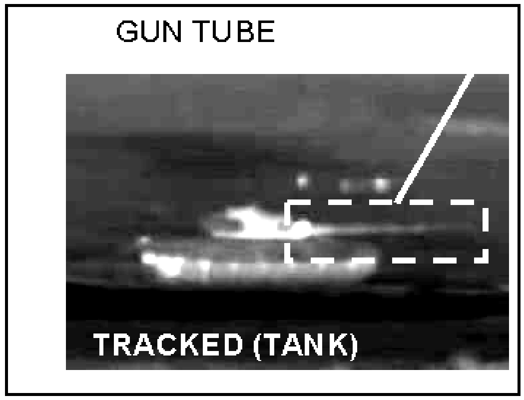


Figure E-58. Classification features—gun tube/barrel.

NOTE: Proper adjustment of focus, contrast, and brightness enables the gunner to classify and recognize targets. Adjust the image so the target features stand out from the surrounding terrain features. It may be necessary to make several adjustments for the same target. See Figure E-59 for examples of poorly adjusted and properly adjusted target images for classification and recognition.

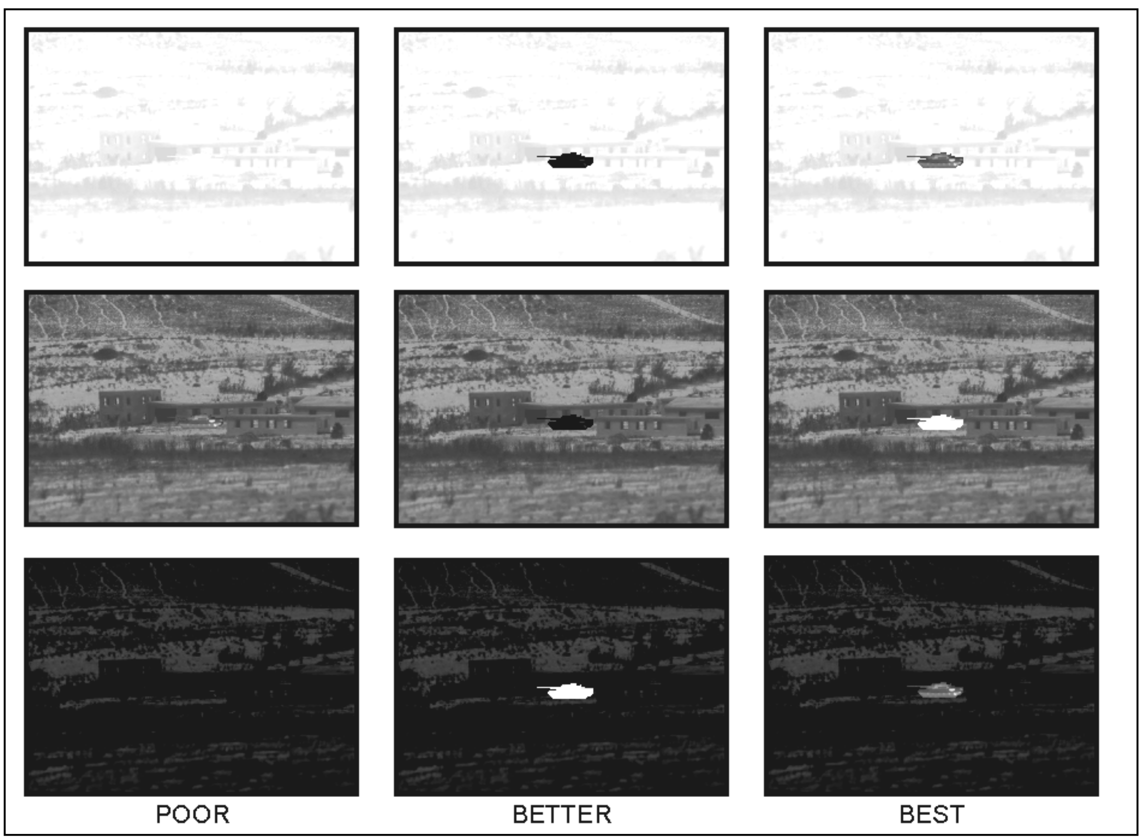


Figure E-59. Image adjustments for target classification and recognition.

c. **Defensive Operations (Moving Targets)**. Some targets may be easier to classify and recognize than others for the following reasons:

(1) ***Range to the Target***. Even under ideal conditions, classifying and recognizing a target at long ranges is difficult due to the NVS magnification and image resolution. As range to the target decreases, target details become clearer, which makes classification and recognition easier.

(2) ***Target Aspect***. Flank targets are easier to classify and recognize than frontal targets (Figure E-60). The profile exposes the suspension and other distinctive features, such as turrets, engine compartments, gun tubes, or other armament.

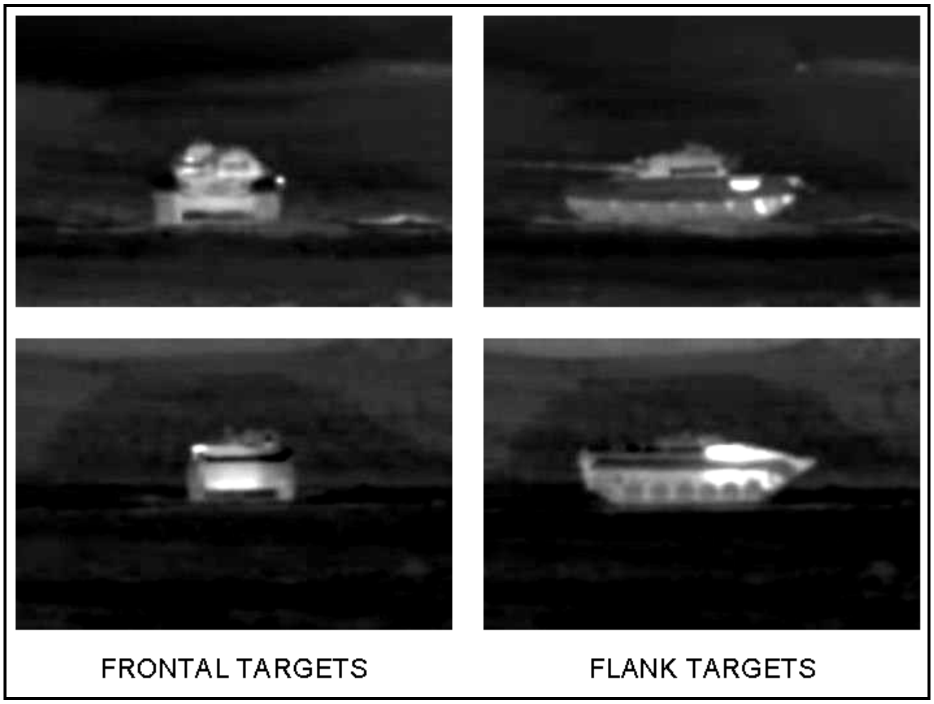


Figure E-60. Classification and recognition features of flank versus frontal target (label APC AND TANK).

(3) ***Target Movement***. A moving target allows the gunner to see it from more than one aspect making it easier to classify and recognize than a frontal target moving in a straight line.

(4) ***Terrain***. Targets try to remain hidden from the gunner by staying in cover and concealment, or by using the terrain to mask their movement. Depending on the amount of terrain masking, the gunner may see only one or two features from which to classify, and recognize a target.

d. **Offensive Operations (Stationary Targets)**. The gunner's ability to detect, classify, and recognize a stationary target depends on:

- Position of the target with respect to the gunner's location.
- Enemy activity.
- Proper image adjustment.
- Amount of target exposure.

E-9. TARGET RECOGNITION

Target recognition is the next step in the process of elimination whether a tracked vehicle is a tank.

a. **Definition**. Target recognition: to determine whether a tracked vehicle is a tank or an APC (Figure E-61).

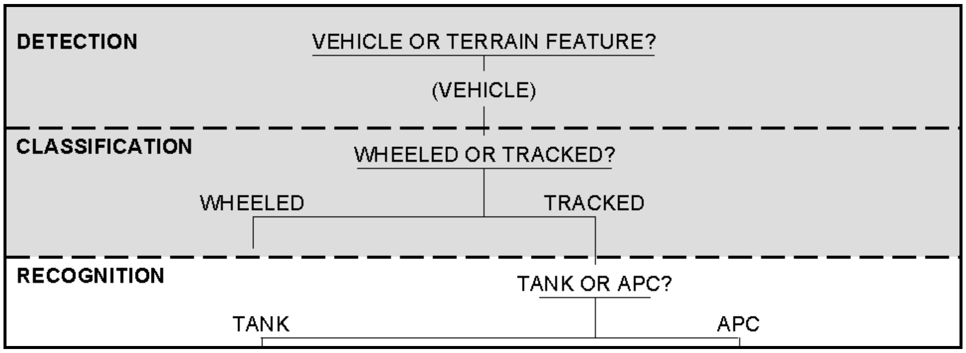


Figure E-61. Target acquisition process—recognition step.

b. **Image Adjustment**. Image adjustment for target recognition is the same as for classification. The gunner should make image adjustments so the target features stand out from the surrounding terrain features. The gunner may have to keep adjusting contrast and brightness to bring out different target details as he tries to attempts target recognition.

c. **Recognition Features**. The major differences between tanks and APCs are shown below (Figure E-62 and Table E-1, page E-38):

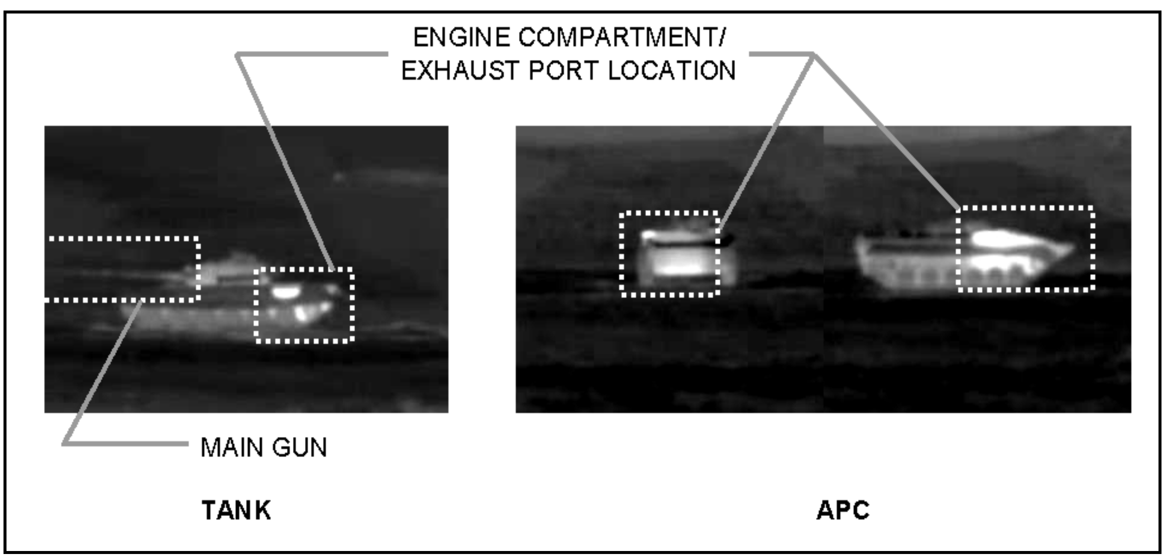


Figure E-62. Target recognition features (ADD FRONTAL AND FLANK LABELS).

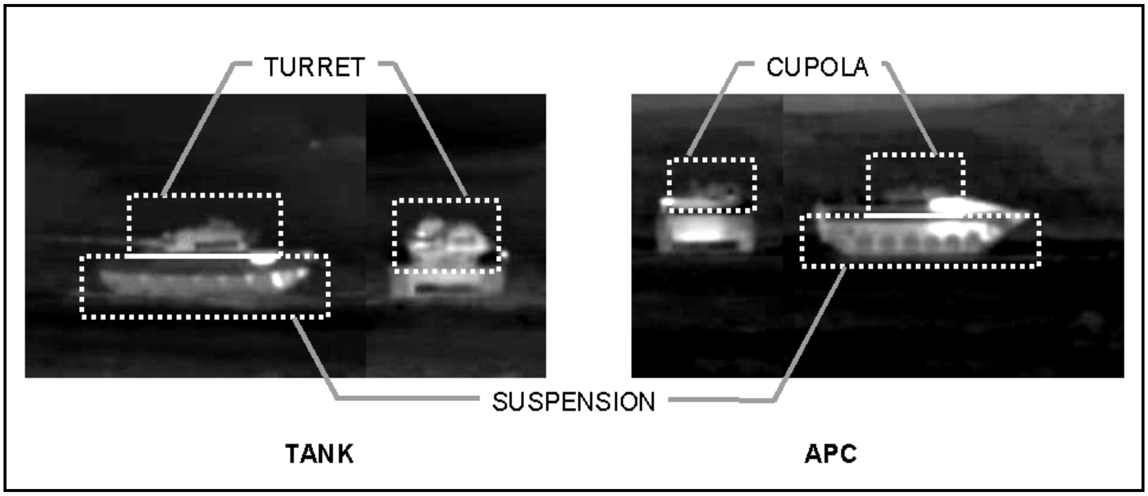


Figure E-62. Target recognition features (ADD FRONTAL AND FLANK LABELS) (continued).

SIGNATURE	TANK	APC
ENGINE COMPARTMENT	LOCATED IN REAR	LOCATED IN FRONT
EXHAUST PORTS	LOCATED IN REAR	LOCATED IN FRONT OR ON THE SIDE
MAIN GUN	LONG AND THICK	SHORT AND THIN
TURRET	YES - AND LARGE	YES, MOST HAVE TURRETS
CUPOLA	NEW TANKS—NO OLD TANKS—YES	YES—USUALLY SMALL
SIZE/SHAPE	LARGE AND SLOPING	SMALL AND RECTANGULAR

Table E-1. Target recognition features.