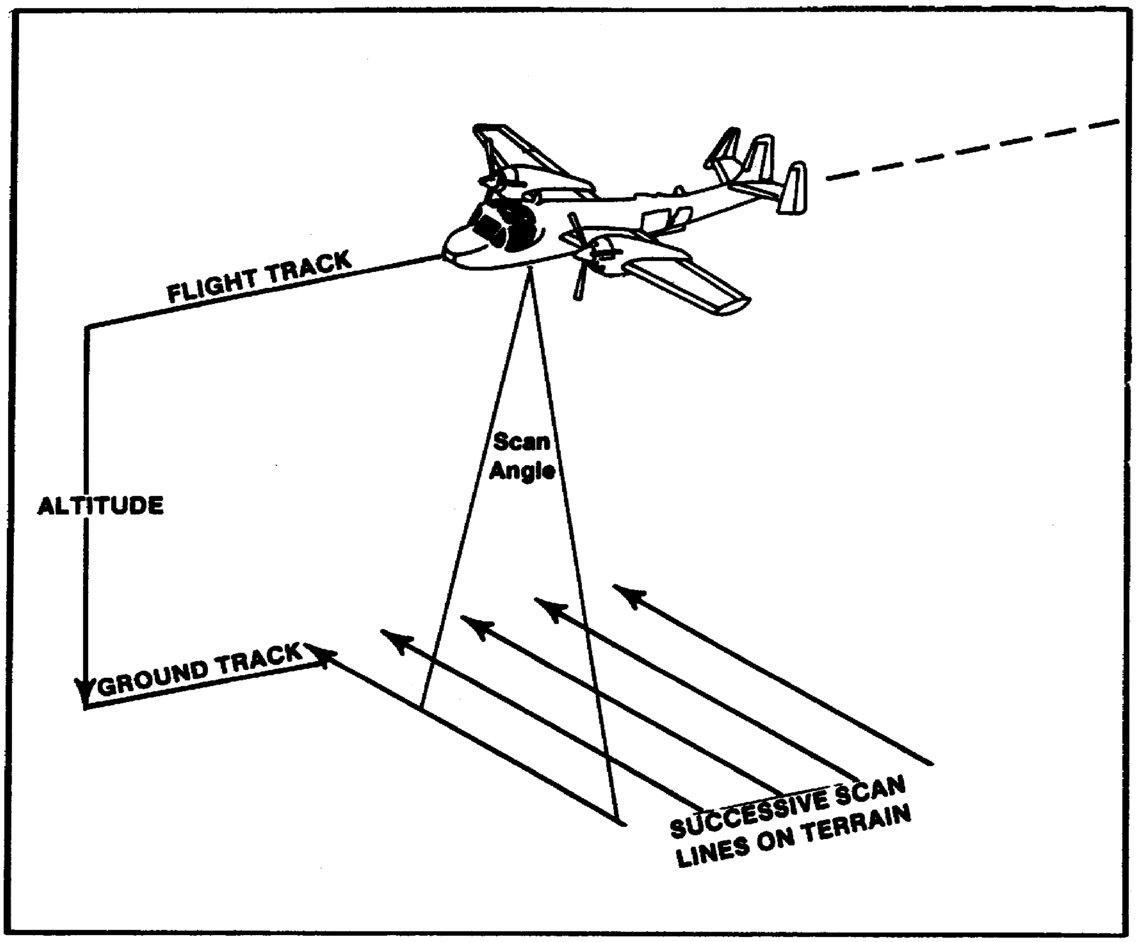
SUBCOURSE IT0654 | EDITION A

US ARMY INTELLIGENCE CENTER AND SCHOOL
INFRARED IMAGERY



THE ARMY INSTITUTE FOR PROFESSIONAL DEVELOPMENT
ARMY CORRESPONDENCE COURSE PROGRAM

INFRARED IMAGERY

Subcourse Number IT 0654

EDITION A

U.S. Army Intelligence Center and School
Fort Huachuca, Arizona 85613-7000

3 Credit Hours

Edition Date: May, 1990

SUBCOURSE OVERVIEW

This subcourse is designed to teach you basic infrared (IR) theory and how to interpret, analyze, and plot IR imagery.

There are no prerequisites for this subcourse.

This subcourse reflects the doctrine which was current at the time the subcourse was prepared.

TERMINAL LEARNING OBJECTIVE

TASK: You will describe basic IR theory and perform interpretation techniques on IR imagery.

CONDITIONS: You will have access to extracts from DA Pam 25-7, STANAG 3277, STANAG 3596, STP 34-96D1-SM, and TC 34-55.

STANDARDS: You will describe basic IR theory and perform interpretation techniques on IR imagery in accordance with (IAW) DA Pam 25-7, STANAG 3277, STANAG 3596, STP 34-96D1-SM, and TC 34-55.

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LESSON ONE

INFRARED IMAGERY ANALYSIS

MOS MANUAL TASKS: 301-338-1841
301-338-3701

OVERVIEW

TASK DESCRIPTION:

In this lesson you will learn basic IR theory, how to analyze IR imagery, prepare IR mission requests, and IR mission reports.

LEARNING OBJECTIVE:

ACTIONS: Describe basic IR theory and the information and procedures required to analyze IR imagery, and prepare IR mission requests and IR mission reports.

CONDITIONS: You will be given access to extracts from DA Pam 25-7, STANAG 3277, STANAG 3596, STP-34-96D1-SM, and TC 34-55.

STANDARDS: Description of basic IR theory, analysis of IR imagery, and preparation of IR requests and reports will be IAW DA Pam 25-7, STANAG 3277, STANAG 3596, STP-34-96D1-SM, and TC 34-55.

REFERENCES: The material contained in this lesson was derived from the following publications:

DA Pam 25-7.
STANAG 3277.
STANAG 3596.
STP-34-96D1-SM.
TC 34-55.

NOTE: Replace pages 16 and 22 with photo pages 16 and 22 attached to the back of the subcourse booklet for better viewing.

INTRODUCTION

IR imagery is a vital asset to the field commander. It is an alternative to conventional imagery. The method for using heat sensing devices, imaging returns, and then providing interpretive information from the imagery has been in existence for nearly 40 years. Some details of operational IR sensors are classified and are not discussed in this lesson.

PART A: BASIC INFRARED THEORY

1. Most people associate IR with temperature rather than electromagnetic energy. This is not entirely wrong. A direct relationship exists between heat (temperature) and IR. For this reason, some understanding of IR is needed.

2. IR radiation. Reconnaissance and surveillance (R&S) systems are based on the ability of the sensors to detect radiation from the terrain below. An increase in the temperature of a body will cause an increase in the amount of IR generated.

3. Electromagnetic energy. IR is electromagnetic energy. All objects having a temperature above absolute zero (above minus 460° Fahrenheit) emit IR. Absolute zero is a point where all molecular activity ceases (Figure 1-1).

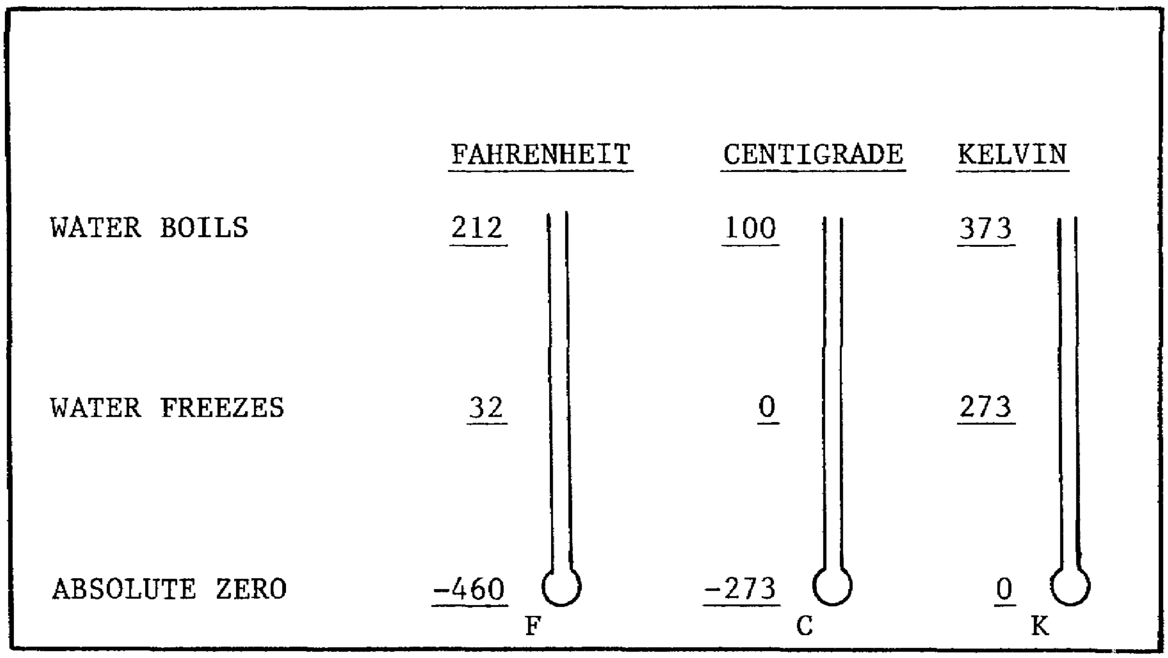


Figure 1-1. Temperature Scale Equivalents.

4. Molecular activity. Atoms and molecules are in a constant state of activity. This activity causes friction as the atoms and molecules bump into each other. This friction raises the temperature of a body of atoms or molecules. External heat also increases the molecular activity and consequently the friction. The result of this phenomenon is that every body of atoms or molecules emits heat. The amount of heat emitted also determines the amount of IR energy in the electromagnetic spectrum (Figure 1-2).

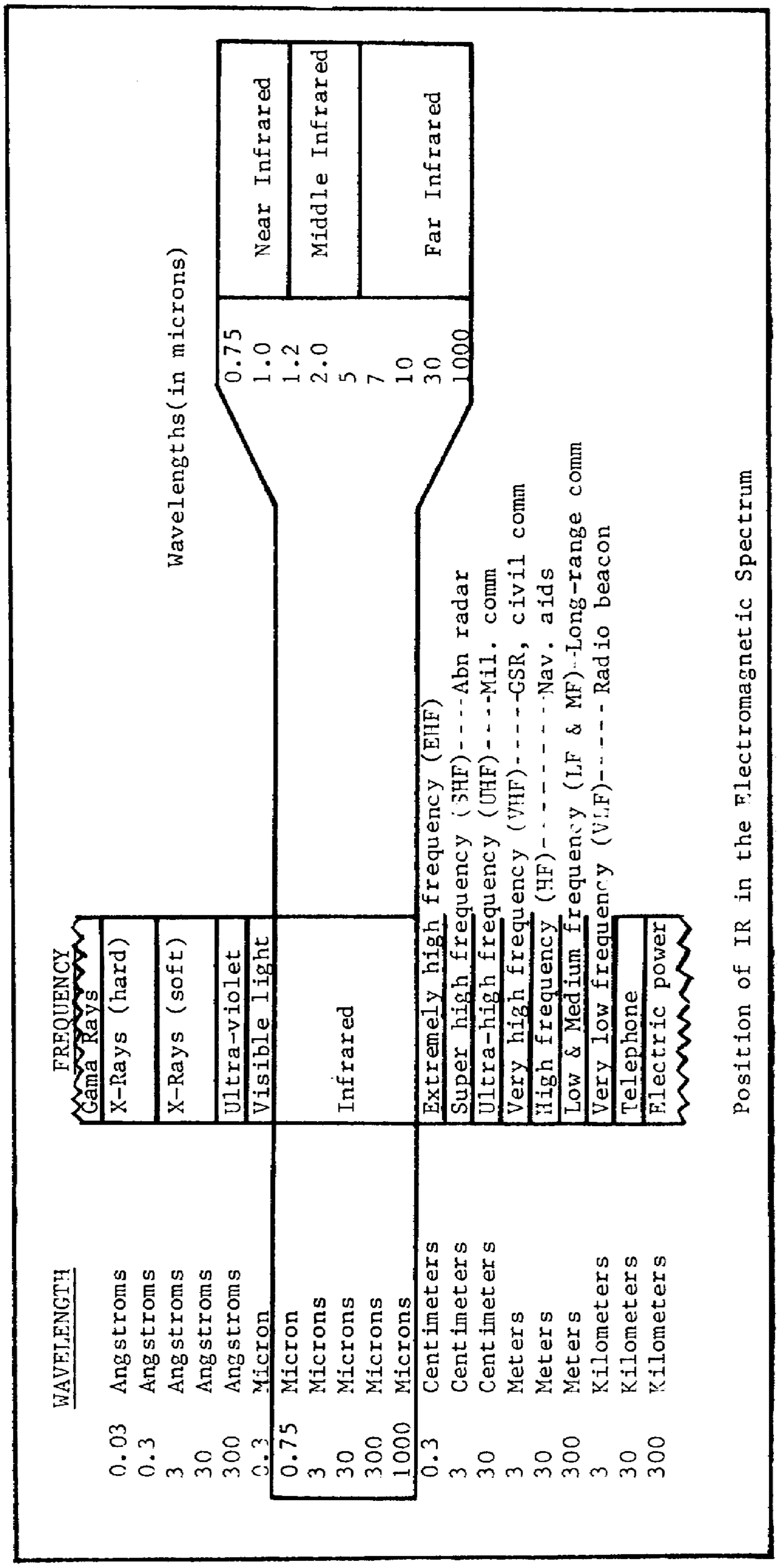


Figure 1-2. Electromagnetic Frequency Spectrum.

5. Material makeup. The amount of IR energy emitted by objects is affected by the material makeup of the objects, shape of the objects, finish or texture, and whether the objects are light or dark in tone (color). The size of the object has no effect on the amount of IR energy it can emit, reflect or absorb. This will be covered in more detail later. All objects with a temperature above absolute zero have an ability to emit, reflect, and absorb energy.

a. Emitted energy is generated by molecular activity.

b. Reflected energy is reflected from an outside source.

c. Absorbed energy is emitted by an outside source and absorbed by an object.

6. IR energy. The primary source of IR on the earth is the sun. IR energy, like visible light, which is also on the electromagnetic spectrum, travels at the speed of light (186,000 miles or 300,000 kilometers (km) per second). It travels in all directions, and like visible light, its intensity or strength will decrease the further it travels away from its source. You can mathematically determine the diminishing energy of a given area using the inverse square law. For example, the amount of energy available for detection at 2,000 feet (ft) would be 1/4th of that at 1,000 ft. The amount of energy available for detection at 3,000 ft would be 1/9th of that of 1,000 ft, and at 4,000 ft the amount of energy available for detection would be 1/16th of that at 1,000 ft. IR energy can be refracted, reflected, focused, measured, and recorded. You should be familiar with all these terms.

a. Refracted light passes through a prism and each color is separated to create a rainbow-like effect. This is exactly what happens when the atmosphere is heavy with moisture. The moisture refracts the light coming from the sun, separates it into its various colors, and a rainbow Is formed.

b. Reflected light occurs with any mirrorlike apparatus.

c. Focused light can be concentrated on one spot. An example is using a lens to concentrate the sun's light on a piece of paper or wood to make it ignite. A laser beam is another example.

d. Measured light. Refer to Figure 1-2, electromagnetic frequency spectrum.

e. Recorded light. Refer to Figure 1-2, electromagnetic frequency spectrum.

7. Electromagnetic frequency spectrum. Electromagnetic energy has been defined in terms of its specific wavelength. The various wavelengths have been placed on a graduated scale

called the electromagnetic spectrum (Figure 1-2). Visible light, for example, is only a minute portion of this spectrum. All other forms of electromagnetic energy can only be seen and measured by mechanical means.

8. IR radiation is divided into three regions based on the location in the frequency spectrum in relation to the visible light range. These regions are:

a. Near --0.7 to 1.2 microns.

b. Intermediate --1.2 to 7.0 microns.

c. Far --7.0 to 1,000 microns.

d. IR radiation wavelengths of .09 to 1.3 microns can be detected by and recorded on IR film used in standard aerial cameras.

e. An overlap occurs on the visible light portion of the spectrum. For example, on a hot day, while driving up an incline, heat appears as water on the surface of the pavement. This is a small portion of IR that overlapped into the visible light portion of the electromagnetic spectrum.

9. Semiconductors. The emergence of solid state semiconductors after World War II has permitted greater sensitivities and response to longer wavelengths. Current operational IR sensors employ semiconductor detectors to record selective infrared emissions from 0.3 to 16.0 microns. IR sensitive film detects radiation reflected by an object; therefore, it required an external light source such as sunlight. The semiconductor-type detectors detect inherent IR radiation from objects. Hence, semiconductors can be used day or night with no external illustration.

NOTE: Detectors used in semiconductor-type IR sensors depend upon that portion of the IR region under surveillance. Semiconductor IR sensors detect emitted energy and convert it to proportional electrical signals. These signals are in turn amplified and converted to usable imagery.

10. IR systems. The IR detecting system used in the Army National Guard is the AN/AAS-24 IR mapping system, mounted in the OV-1D Mohawk aircraft. The US Air Force has the AN/AAD-5 IR reconnaissance set, mounted in the RF-4C aircraft. These systems scan the terrain directly below the aircraft and record detected temperature variances. The US Air Force also has the AN/AVQ-26 Pack Tack line-of-sight, forward-looking IR reconnaissance sensor; it can be mounted under the RF-4C, F-4E or F-111F aircraft. The AN/AVQ-26 has two basic operating modes of search and track. The search mode is used to locate the target. The track mode is used to accurately track targets after acquisition. These systems do not emit signals like radio or radar. For this reason, IR detecting systems are considered

passive. An active system would De one in which a signal leaves the aircraft and records a return echo like in side-looking airborne radar (SLAR).

NOTE: Both the AN/AAS-24 IR mapping system and the AN/AAD-5 IR reconnaissance set do not have a standoff capability. They must De used with discretion by the commander, taking into account the safety of the air crew and the aircraft.

11. IR peculiarities. It was previously stated, all objects having temperatures above absolute zero emit IR energy. However, IR detectors are not able to receive all of the energy emitted by an object for the following reasons:

a. Atmospheric attenuation. IR radiation Is attenuated by atmospheric particles such as rain, fog, snow, sleet, and dust. Under such conditions, the particles reduce the radiation received by the airborne IR detector. As the size of atmospheric particles approaches a size near the wavelength of the radiation, detection becomes Increasingly difficult. For this reason it Is preferable to fly missions at "low' altitudes (less than 1,000 feet(ft)). At low altitudes there is less atmospheric attenuation between the target and the sensor. IR energy also attenuates with distance. Higher sensor altitudes coupled with atmospheric attenuation can reduce IR radiation to a point beyond the sensor's capability to detect it. Figure I-3 shows how the transmission of various IR wavelengths is affected by the atmosphere. The shades areas depict regions of best IR transmission through the atmosphere. The regions of high transmission of IR energy are called "atmospheric windows." The largest "window' is between 7.5 and 14 microns at mean sea level (MSL). An increase in elevation (not altitude) results in larger window because of the decrease In the density of the atmosphere.

NOTE: Astronomers locate their observatories on mountain tops where the atmosphere is less dense and pollutants are negligible.

b. Thermal crossover. The amount of IR radiation is directly related to the temperature of an object.

(1) As temperature Increases, the energy level of emitted IR also increases and the hotter surfaces emit shorter IR wavelengths. As solar energy strikes the earth during the daylight hours, different objects heat at different rates. Thus, during the day, land is warmer than water. At night, cooling also occurs at different rates leaving water areas warmer than land surfaces.

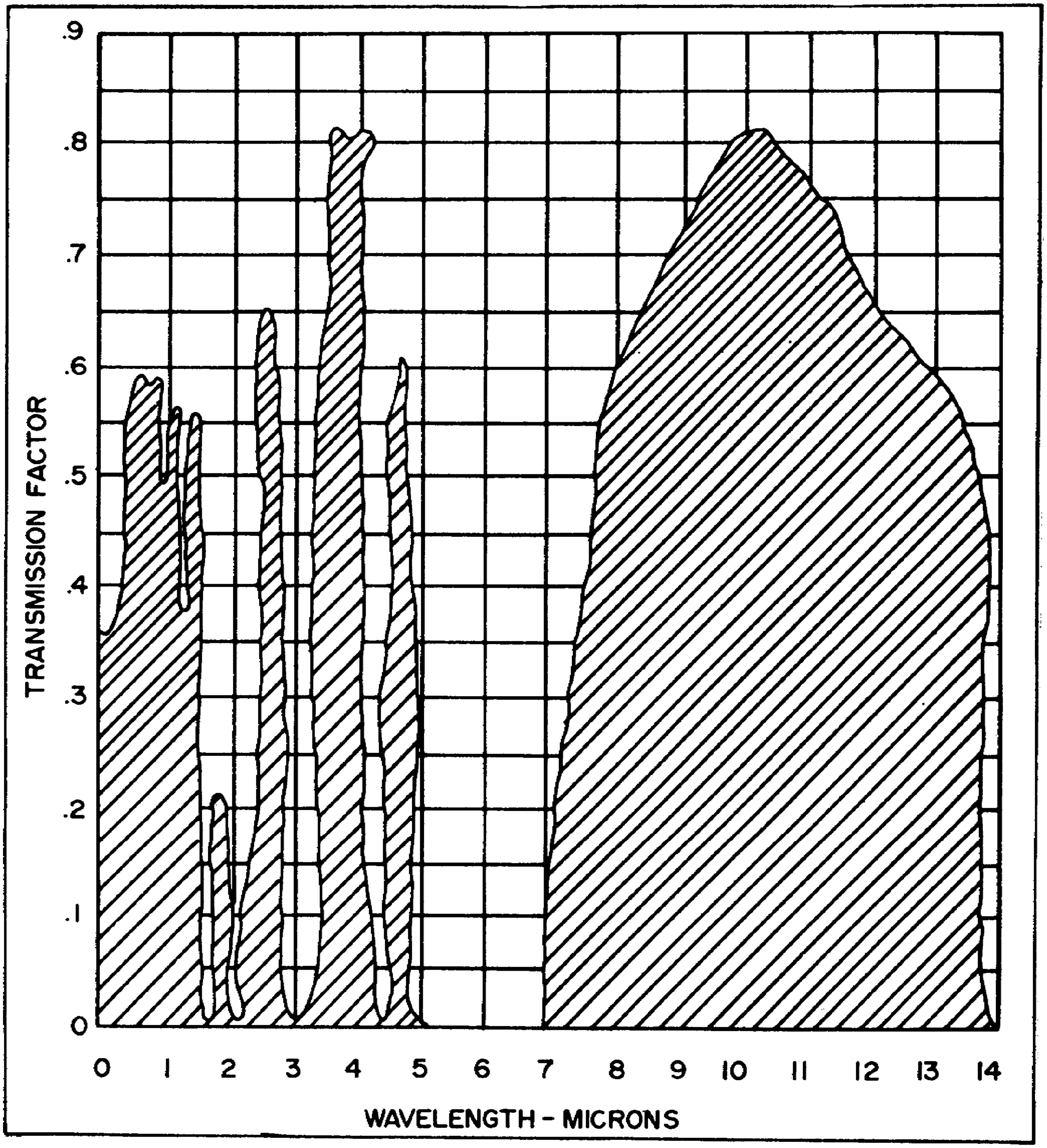


Figure 1-3. Atmospheric Windows.

(2) Because of the interchange of night and day, there are two times daily (early morning and early evening) when land and water surfaces are equal in IR output. A prime example is a steel bridge spanning a large body of water. The water absorbs heat during the day and releases it slowly at night, thus causing a minimal change in its IR output. However, the initial composition of the bridge causes it to heat rapidly from the sun's energy and cool rapidly at sunset. As the bridge cools, it will reach the same temperature as the body of water. At this point, the bridge will not be visible on IR imagery. Eventually it will get colder than the body of water and reappear. The point at which invisibility occurs is called 'crossover time.' It also occurs in reverse at sunrise.

c. Blackbody effects. A blackbody is a theoretical material in that it effects and radiates the total IR energy received when the IR energy source is removed. In a natural environment a body of water comes closest to achieving this state. During the day water will absorb IR energy and at night it will radiate IR energy. This phenomenon is called the blackbody effect. Water will appear very light on IR imagery taken in the day and very dark on night imagery.

d. Emissivity is the ratio of IR emitted by a surface to the IR radiation emitted by a blackbody at the same temperature and under the same conditions. The emissivity of a body is dependent on: the material it is made of, its shape, the finish or texture of its surface, the light or dark color of its body, its temperature and external sources of electromagnetic energy. The emissivity-of various materials in relation to a blackbody is listed in Table 1-1, starting with the perfect emissivity, factor of 1.00 (absorbing and radiating the total IR energy received). The following categories are generalized target descriptions (assuming a target and its background have the same emissivity:

(1) Warm target: A target that is warmer than its background will image brighter than its background on IR positive film.

(2) Hot target: A target that is much warmer than its background will image much brighter than its background on IR positive film.

(3) Cool target: A target that is cooler than its background will image darker than its background on IR positive film.

(4) Cold target: A target that is much colder than its background will image much darker than its background on IR positive film.

Table 1-1. Emissivity.

Type of Material	Material	Emissivity Factor
Theoretical	Blackbody	1.00
Metals	Aluminum (polished)	0.08
	Copper (polished)	0.15
	Galvanized Iron (oxidized)	0.28
	Copper (oxidized)	0.60
	Steel (oxidized)	0.70
Building Materials	Gypsum	0.90
	Red Brick	0.93
Paint	Aluminum	0.55
	Black (glossy)	0.90
	Green	0.95
Miscellaneous	Lamp Black	0.95
	Water	0.96
	Snow	0.82-0.96

12. Reconnaissance sensors. IR reconnaissance sensors have been developed to detect invisible IR emissions. Unlike aerial cameras which use lenses to expose photographic film to light reflected from the subject, the IR sensors employ a combination of optics, electronics, and mechanical devices to produce the image. The three basic units in an IR reconnaissance set are (Figure 1-4):

- Scanner optics.
- Detector.
- Recording unit.

a. The scanner receives or collects a portion of the IR energy radiated from the area being scanned. This collected energy is focused onto a detector that is sensitive to the IR region of the electromagnetic spectrum.

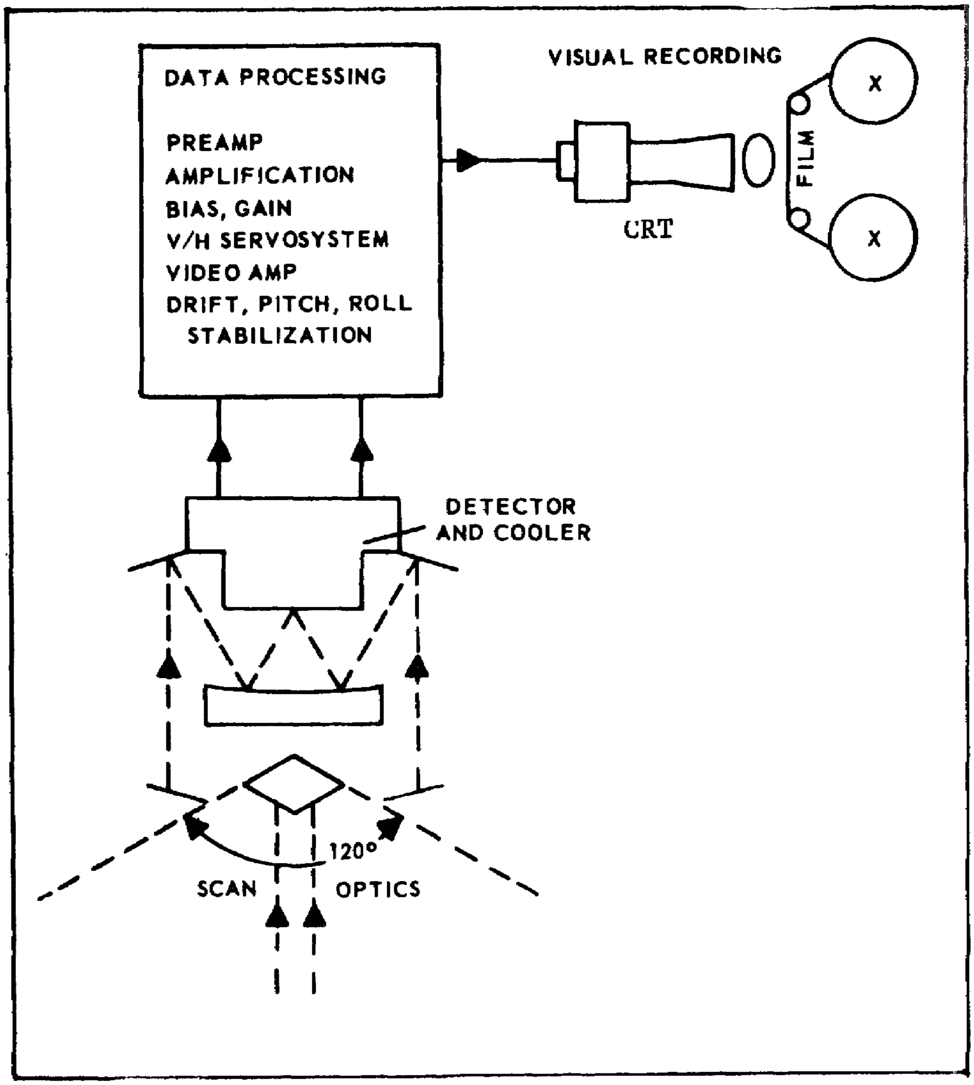


Figure 1-4. IR Reconnaissance System.

NOTE: 120° shown in Figure 1-4 indicates the scan angle for this system.

(1) The basic IR scanner consists of a rotating scan mirror and a series of reflecting and focusing mirrors. The scan mirror rotates at high speed vertical to the aircraft track. At the start of a line scan only objects at the left end of the scan are focused into the detector. Energy from other areas is reflected away from the folding mirrors. After the scan mirror has rotated halfway through the scan, only energy from objects directly below the aircraft are reflected to the detector. Further rotation of the scan mirror feeds energy into the detector' from objects located at the right end of the scan line. All other energy Is reflected away from the folding mirrors, thus eliminating its detection. When one face of the scan mirror is parallel to the horizon, all energy is reflected to the ground. At this time the Image from the aircraft is reflected on itself. Because of the cool-down of the detector a sharp cold spike is generated in the system. Shortly after this the scan mirror Is in position to start another scan.

(2) The scan technique allows small areas directly below the aircraft to be scanned in a line. The converted line scan IR energy is then produced as successive lines on the recording device. The area that can be viewed by the scanner at any given instant is called the instantaneous field of view (IFV), as shown in Figure 1-5. The ground resolution capability of an IR system depends on the size of its IFV. Such factors as inaccurate detector response, lack of target-to-background contract, recorder error, and uncompensated aircraft motion all tend to degrade IR target ground resolution.

b. The detector transforms the incoming IR signals into proportional electrical signals. These signals are then amplified and fed into a recording unit. The detector is the heart of an IR reconnaissance system. Crystals sensitive to radiation of varying wavelength are used for IR detection. Since all matter above absolute zero temperature radiates IR energy, the detector crystal itself must be cooled to near absolute zero. This cool-down reduces receiver noise caused by internal IR radiation. This noise reduction is necessary for the detection of IR energy collected by the scanner system.

(1) IR wavelengths change with changes in temperature. The average temperature range of specific types of targets must be considered in selecting detector materials. The actual material used as a detector and the temperature to which it must be cooled depends on the wavelength of the IR radiation under surveillance.

(2) When IR radiation is focused into the detector crystal, an electrical signal is proportional to the fluctuation of the incoming IR energy along the scan line. These electrical signals are amplified and transmitted to the IR set recording unit.

c. The recording unit converts the amplified IR signals into a variety of usable forms recorded on film, video tape, or a cathode-ray tube (CRT) viewing screen. A number of methods are used to produce identifiable images from IR line scan information. A common method is to use the amplified signal from the detector to develop a light source such as a CRT (Figure 1-6).

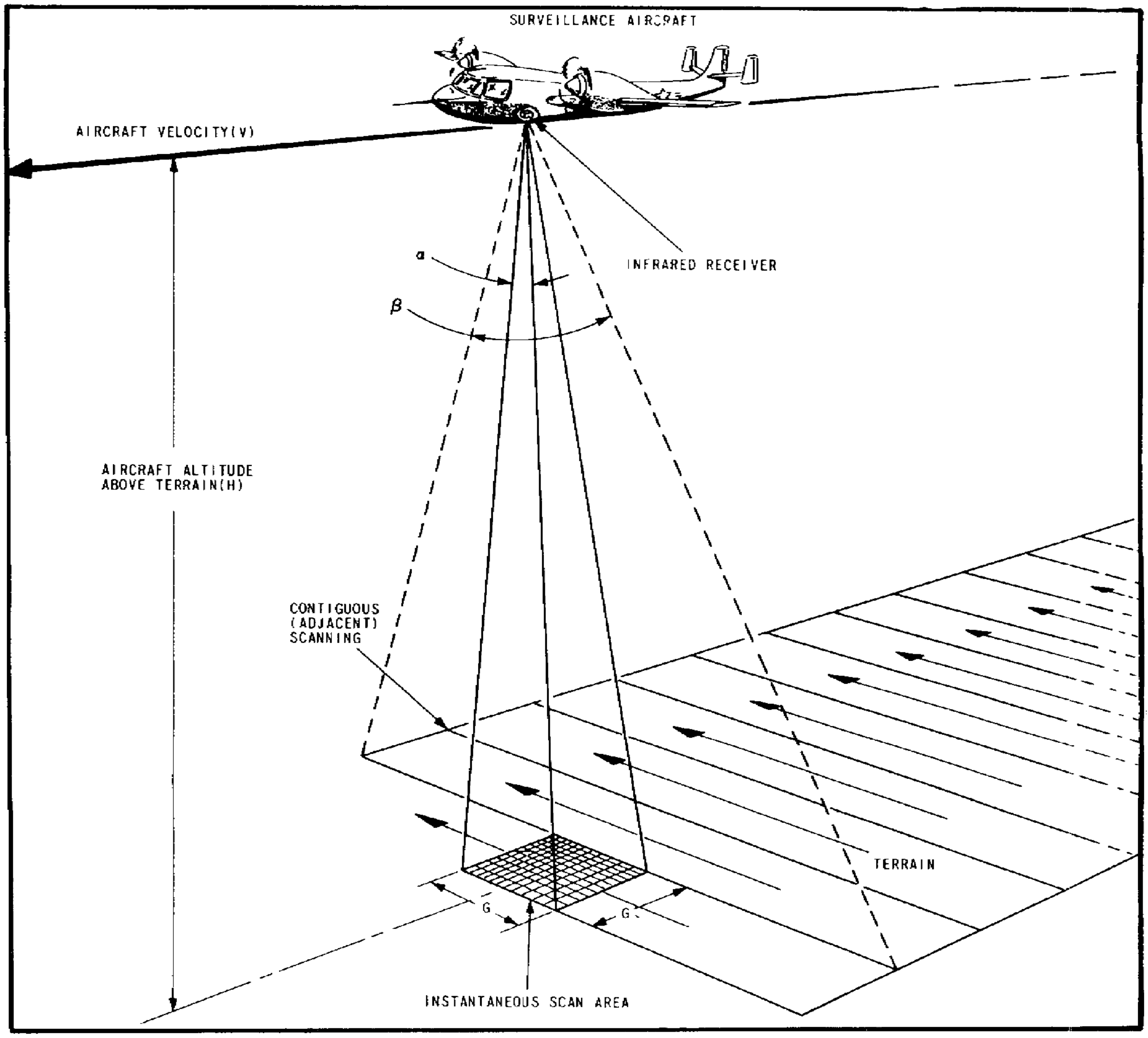


Figure 1-5. IR Scanning.

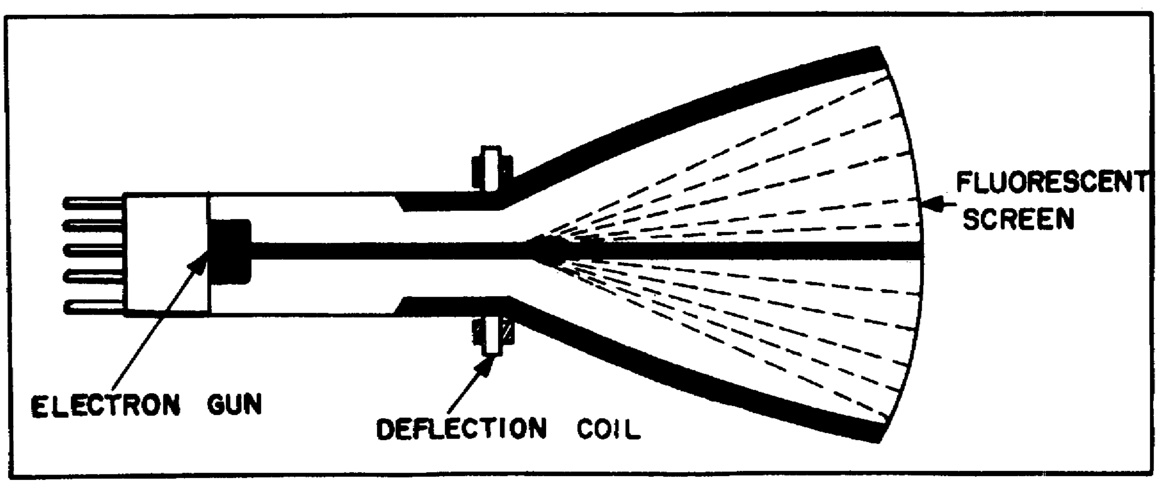


Figure 1-6. CRT.

(1) The light from the tube is then focused onto standard aerial photographic film. The photographic imagery then consists of a series of line scans perpendicular to the aircraft track as shown in Figure 1-7. Because of temperature differences between surface targets the imagery will resemble a continuous strip photograph of the area.

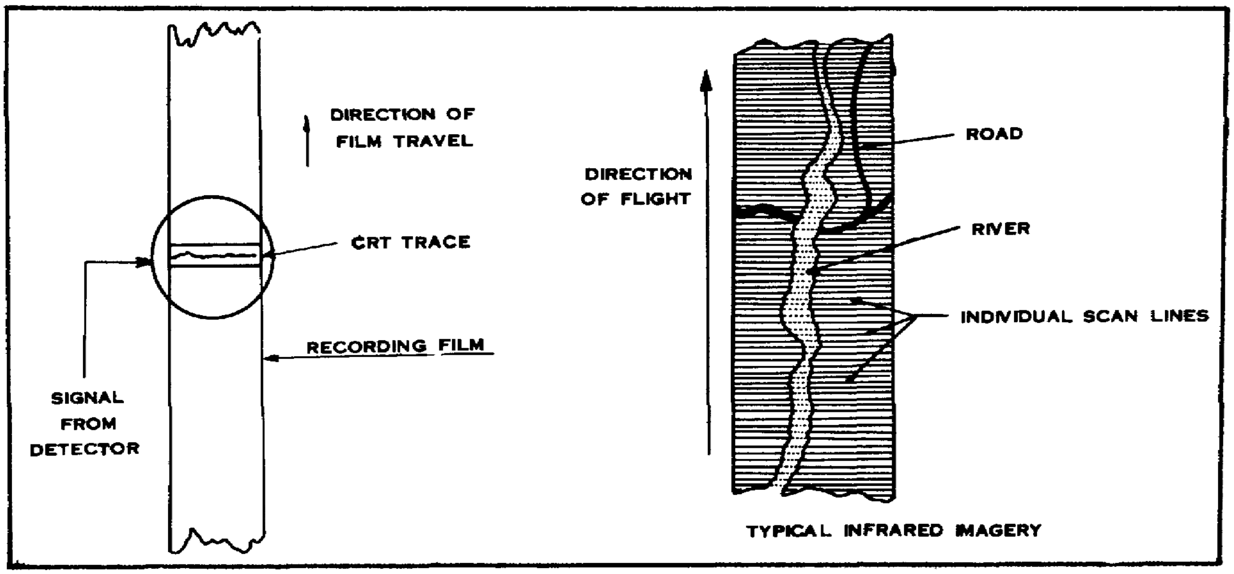


Figure 1-7. Recording Line Scan Information.

(2) Image information can also be recorded on video tape. This video tape can then be played back on special viewers after the mission. A third possible method of using IR imagery is to portray the individual line scans on a television-type, real-time viewer. A moving map-like presentation of the area scanned by the aircraft can be seen on the screen.

13. Limitations. All things have their limitations, IR included. An IR strip does not have a perspective center and thus lacks the radial perspective of conventional photography. Line scan patterns may be bold imagery acquired at low altitudes and fast aircraft speeds or subdued imagery acquired at high altitudes and slow aircraft speeds, depending upon the conditions of scanning. Distortions in IR imagery hampers the imagery analyst's (IA) ability to make measurements; they are a direct result of:

a. Scale compression which gives imagery the appearance of ground features being wrapped around a cylinder. As the 'look angle" increases, larger and larger ground distances are compressed into equal image distances.

b. Incorrect velocity over height (V/H) is the result of unexpected changes in terrain clearance caused by abrupt changes in elevation in areas of moderate to high relief and/or erroneous ground speed information. If film speed is too slow, objects are compressed; if it is too fast, objects are elongated in flight direction.

c. Aircraft motion which is a result of roll, pitch, yaw, or drift (Figure 1-8).

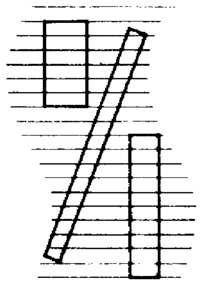
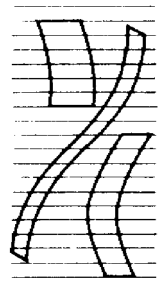
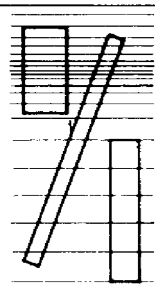
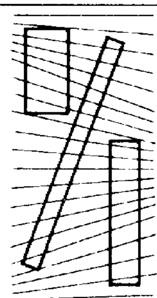
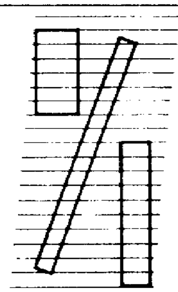
	Aircraft Motion	Scan Mode	Recording Mode	Identification
Direction of Flight ⟶	**Roll**	 Scan Raster Displaced Sideways	 Images Displaced Sideways	Wavy appearance of straight lines (roads). Cyclic displacement of imagery synchronized with the aircraft rolling.
	Pitch	 Uneven Scanline Spacing	 Images Compressed and Stretched	Compresses and elongates images of objects (occurs less frequently than roll).
	Yaw	 Scan Lines Skewed	 Image Edges Skewed or Displaced	Compresses and elongates images of objects laterally across the film. Wedging takes place and image edges are skewed.
	Drift	 Scan Lines Displaced Uniformly	 Images Displaced Uniformly	Rectangles are distorted into parallelograms. Angle of distortion is approximately equal to the drift angle. Under normal conditions of drift (less than 10°) this distortion will be quite small.

Figure 1-8. IR Distortions from Aircraft Motion.

PART B: INFRARED ANALYSIS TECHNIQUES

1. The analysis of IR imagery requires that you become familiar with some of the same basic characteristics used in the analysis of conventional photography. This includes size, shape, shade (tone) shadow, and surroundings (pattern and site).

NOTE: On negative IR imagery, hot targets will appear black, and cold targets will appear white. When a print (positive) is made from the film negative, the reverse is true. Specific aspects of IR imagery discussed in this subcourse are based upon film negative imagery unless specifically stated otherwise.

2. Five "Ss" are size, shape, shadow, surroundings, and shade and are applied in a slightly different manner than in regular photography.

a. Size and shape. You can use size and shape characteristics if you keep in mind the resolution limitations of the IR system. IR imagery may not often portray the true size and shape of objects. This is because of three major effects:

(1) Halation or blossoming. A "halo" effect appears on imagery when an object is considerably hotter than its surroundings. This creates an aura which enlarges the object on the imagery.

(2) Incorporation is achieved when a large object touches or covers a smaller object. This results in one large target on the imagery giving misinformation regarding target size, shape, and numbers.

(3) Overloading. The IR recording system can be overloaded when sensing an object is too hot for its established range. When this happens the imagery will reflect a large, unidentifiable mess. The apparent shape may not indicate the object's true shape.

NOTE: Size and shape characteristics can be used in detecting decoys. Annotation A in Figure 1-9 shows decoy helicopters and Annotation B depicts actual helicopters.

b. Shadows. A unique feature of IR imagery is shadows. Shadows will appear on daylight imagery and be missing on nighttime missions. Shadows are referred to as either "thermal" or "ghosting."

(1) Thermal shadows can include the same areas as visible shadows. They are caused by the ground surface temperature being lower in the area shaded from direct radiation and from a reduced amount of near-IR solar radiation reflected from the shaded area. True thermal shadows are present during daylight hours. This is caused by shading from buildings, trees, or other elevated objects. These shadows usually dissipate shortly after sunset or when cloud cover is present. Dissipation rates vary depending on the physical characteristics of the

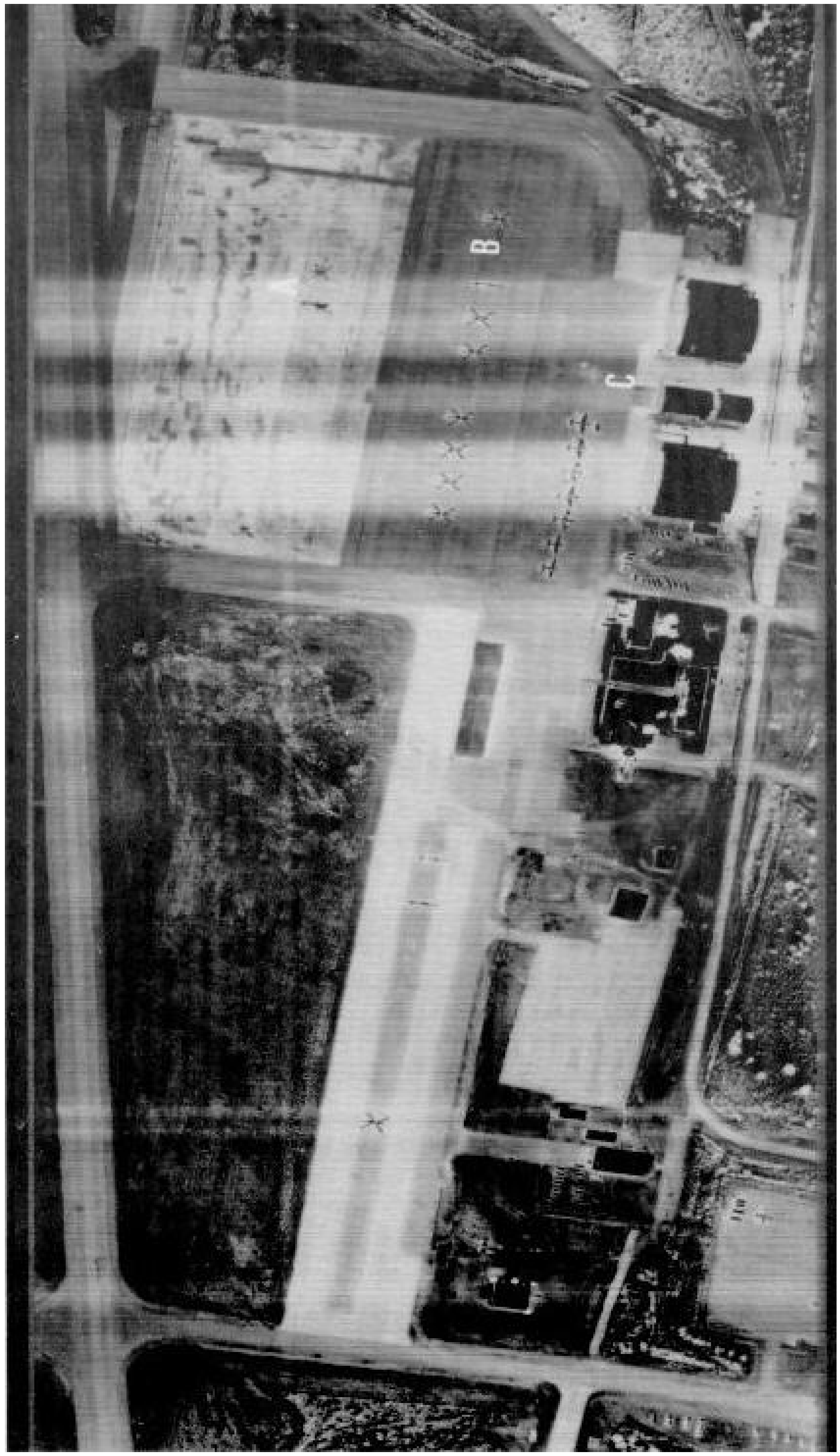


Figure 1-9. Positive IR Print of Decoys and Ghosting.

shaded area and upon prevailing meteorological conditions. Thermal shadows can often be detected for hours. An additional type of thermal shadow can be noted on the lee side of projecting objects during windy conditions. This occurs because the wind does not disturb the surface in the area behind the object (lee). Consequently, this area may be warmer or cooler than the surrounding area, depending upon whether the breeze is warming or cooling the surface over which it is blowing.

(2) Ghosting can best be explained by example. Before taking off, a jet pilot usually warms up the aircraft's engines. This causes the air, runway, or apron surface behind the engines to heat. After the plane has departed, the area will remain hotter than the surrounding area. In addition, the shadow area cast by the aircraft will be cooler than the surrounding area. An IR mission flown over this area soon after the aircraft has departed will easily detect the outline of the aircraft, cool area, and the area of warm jet exhaust (Annotation C, Figure 1-9).

c. Surroundings. A knowledge of the surrounding area and pattern forms is vital to the identification of targets or extremely hot objects. This may require maps or ground data for accurate identification. One important fact to note when interpreting surroundings is that disturbed soil tends to show up very clearly on IR imagery. Disturbed soil has a different temperature value than hard packed soil; therefore, a missile site and its configuration will normally show up on IR imagery because of the disturbed soil and thus reflect actual returns. The radar associated with the site will show up as a warm spot at its location within the site. The passing of a vehicle across an open field will be easy to detect because of the disturbed soil. This may be helpful in locating hidden targets.

NOTE: IR can detect the difference in normal soil and disturbed soil for months and even years. Currently archeologists are using IR to help detect ruins. Consequently, great care must be taken when reading IR imagery to assure any disruption of surroundings is current and/or pertinent.

d. Shade or tone. The temperature difference of objects determines the tone of IR imagery. This is a key factor to interpretation because the tone differentiation provides clues to the composition or activity of objects. For example, a decoy would produce a lighter tone than an actual object (Annotation A versus Annotation B, Figure 1-9); a campfire would produce a different shade of black than would an operating generator or a running vehicle. This stress on tone is the major difference between the interpretation of IR imagery and conventional imagery. The gray tones on IR imagery result from the IR reflectiveness of objects and not their color.

3. Materials versus film tone. fable 1-2 consists of a list of materials and their film tones which normally may be expected under specific conditions on IR imagery.

Table 1-2. Materials Versus Film Tone.

Material	TONE Daytime unfiltered	Daytime filtered	Nighttime unfiltered
Earth, hard packed	Gray	Gray to dark gray	Light gray.
Earth, newly turned	Black	Dark gray to black	Gray to dark gray.
Vegetation	Dark gray to black	Gray to white	Light gray to white.
Metal, painted	Black or gray	Light gray to gray	Light gray to white.
Metal, polished	Black	Light	Light.
Water	Dark gray to black	Light gray	Dark gray to black.
Canvas (tents)	Gray to dark gray	Dark gray	Light gray to gray.
Asphalt	Gray to dark gray	Dark gray to black	Dark gray to black.
Concrete	Light to gray	Gray to dark gray	Dark gray to black.
Grass	Gray	Gray	Light gray.

4. The following detail indicates the various factors that affect tone.

a. Weather. Although the IR surveillance system is capable of providing usable results in about 75 percent of all weather conditions, varying weather conditions definitely affect data results, and therefore, influence mission planning.

(1) Heavy snow and rainstorms greatly reduce the R1 energy available for detection, making it nearly impossible to obtain usable data.

(2) Heavy thick fog has a somewhat similar effect to that of rain and snow because of its high water vapor content.

(3) Although the IR detecting set has the ability to see through clouds of thicknesses up to approximately 20 ft, clouds have rather highly reflective surfaces. It may be necessary to filter out the visible light region. High altitude clouds cast shadows on the ground being cooler than the areas casting the shadows. The shadowed areas appear lighter when clouds prevent the solar energy from striking the earth. The cloud density and the type of material in the shadowed area affect the data received from that area.

(4) After long periods of continuous overcast or rainfall, the terrain may lack sufficient 1R radiation contrast to provide detailed data. Since little additional solar energy is available, materials which normally heat and cool at different rates have had time to reach the same temperature levels, thus providing little contrast. In the water-saturated condition, all materials tend to assume the same emissivity level of the water itself.

(5) Bright sunny weather provides large amounts of energy to be absorbed by the terrain, and the different heating and cooling rates of materials provide better contrasts in the IR region.

(6) Winds have different effects on the thermal presentations of targets. All small thermal emitters on a snowy surface may be erased by a wind of 1 or 2 miles per hour (mph), while targets such as roads or manmade objects may not be affected by winds as high as 10 mph.

b. Seasons of the year also influence IR surveillance results and the appearance of the data on the film.

(1) In the summer the terrain generally is subjected to good weather conditions and terrain features generally show up well. Vegetation is more abundant and ground temperatures are higher, which is evidenced by darker images.

(2) During the winter ground temperatures are much lower and overcast days are more prevalent and most of the summer vegetation has disappeared. A large body of water that appeared slightly cooler (lighter) than its surroundings during a summer day now generally appears warmer (darker) than its surroundings. Snow covered terrain also affects IR surveillance results. Larger temperature differences between heated materials and the background occur. Because of this, much larger contrasts in received IR energy may be expected. Careful adjustments of gain, contrast, and level must be made in the IR surveillance system during such a time to prevent exaggerated effects. Generally, In snow conditions, manmade heated objects are easy to detect, but general terrain features may be obscured because snow coverage tends to give all materials the same emissivity level of the snow itself.

(3) Spring and fall are simply transition periods of summer and winter, and they follow the trends of one or the other depending on the general weather conditions. Spring tends to be an extension of winter, while fall tends to be an extension of summer in the collection of IR data.

c. Time of day. Care must be taken during interpretation as to the time of day, especially during the transition or crossover time.

d. Filters are used to exclude certain regions of the electromagnetic spectrum or to pass a specific region.

e. Equipment control settings. The control settings of the components of the IR surveillance system also affect tones:

(1) Gain. A control which determines the amount of signal made available for recording and display control purposes.

(2) Contrasts and level. A fine gain control that regulates the intensity of the printed data representing the received energy.

f. Materials. The following generalizations on the appearance of metal, pavement, soil, grass, trees, and water on negative night IR imagery can be made:

(1) Metal surfaces. Under normal conditions on negative night IR imagery horizontal surfaces of thin unheated bare metal will appear white, because they are cold. Since the emissivity of metals is lower than other substances they will emit less energy. Metal surfaces are good reflectors and will strongly reflect the radiation directed on them from the sky. At night the intensity of sky radiation is quite low (particularly on clear nights), and the reflected radiation will be weak. It is possible for metal to reflect the radiation from nearly warm objects and thus appear to be warm. This effect does not occur often enough to be significant.

(2) Asphalt pavement appears dark gray to black on negative night IR imagery. This is because pavement has a good emissivity and is in good thermal contact with the earth, which acts as a constant heat source. The pavement will retain the heat received from the sun during the day because of its high thermal capacity. This is generally true for all types of pavement, including concrete, asphalt, and blacktop.

(3) Earth. Under normal conditions, earth which includes various types of soils, sands, and rocks will appear dark gray on negative night IR imagery. This results from the sun heating of the earth during the day and its high emissivity and heat capacity.

(4) Grass appears gray to white on negative night IR imagery. Grass is unable to draw heat from the earth because of its poor thermal contact with the ground and rapidly becomes cold by radiation. This results in night inversion because temperatures are lower at night.

(5) Trees appear light-to-medium gray in tone on negative night IR imagery. This tone is believed to be associated with the convective warming of the trees by the air in conjunction with the night inversion of air temperatures, although sun heating from the previous day and natural heat producing reactions resulting from life processes in the trees play a role. In daytime the same leaves appear colder than the ground because the air temperature at tree top height is cooler than at ground level. Shadow areas in the foliage of trees also are cool relative to areas illuminated by the sun.

(6) Under normal circumstances water will range in tone from dark gray to black on negative night IR imagery. This warm tone is the product of its high emissivity and good heat transfer properties. The fluid nature of water allows it to transfer heat by convection as well as by conduction.

REMEMBER: On positive IR imagery (prints) materials will appear in contrast to negative IR imagery, i.e., black on negative IR imagery will be on positive IR imagery, etc.

5. Filtered daytime IR energy is reflected from surfaces in almost the same manner as visible light. In daytime it is possible for an imaged target to be formed solely by reflected near-IR energy. Most surfaces become poor reflectors as wavelengths or reflected energy becomes longer in the IR region of the frequency spectrum. If a filter is used which eliminates not only the visible light energy but also part of the near-IR energy, more nearly pure thermal images can be formed. With appropriate filters it is possible to eliminate energy contributions from any portion of the frequency spectrum during daylight operations. To eliminate visible light and the near-IR frequencies, a specific micron cutoff filter is used. To eliminate energy contributions in the micron region, another type of cutoff filter is used. Filtered daytime IR imagery gives a thermal presentation in which heat sources, such as fires or warm waste water from a power plant, or objects such as housetops and operating vehicles, stand out particularly well.

6. Mission planning summarization. During mission planning make sure you plan the mission for a specific time period that takes into account all factors needed for an optimum mission; low altitude, clear weather, and hours of darkness. This does not mean the aircraft cannot fly at a higher altitude and during hours of daylight or during marginal weather. The imagery will not be as good as that obtained from a mission flown under optimum conditions.

7. Comparison of IR imagery with conventional photography. In Figure 1-10 "A" shows a typical example of the thermal image of an industrial target produced by an IR sensor. For comparison a photograph of the same target is shown in Figure 1-10 "B". It is immediately apparent the size and shape of the large structures are determinable from either image.

a. Smaller targets, such as parked automobiles, are detected in the IR image but clues for identification must be obtained from parking patterns and proximity to roadways. The IR image is a positive print; thus, hot targets appear light and cold targets appear black. The large white structure is an active source, containing a number of furnaces contributing significantly to the IR radiation. Note the row of white dots parallel to the hot building. In the aerial photo these may be identified as smokestacks. The IR image indicates the activity of each stack. The largest stack (below the row of smaller stacks) has no smoke coming from it, yet the IR image shows it to be quite hot.

b. The images shown in Figure 1-10 were obtained in late afternoon. Long shadows appear in the photograph. The residential buildings east of the plant are emitting significant IR from roof surfaces exposed to the sun. Trees behind these dwellings are poor emitters. The line structure of the IR image is very apparent. Each line corresponds to one scan of the IR scanner. The lines are most noticeable in the gray areas which represent intermediate values of IR radiation.

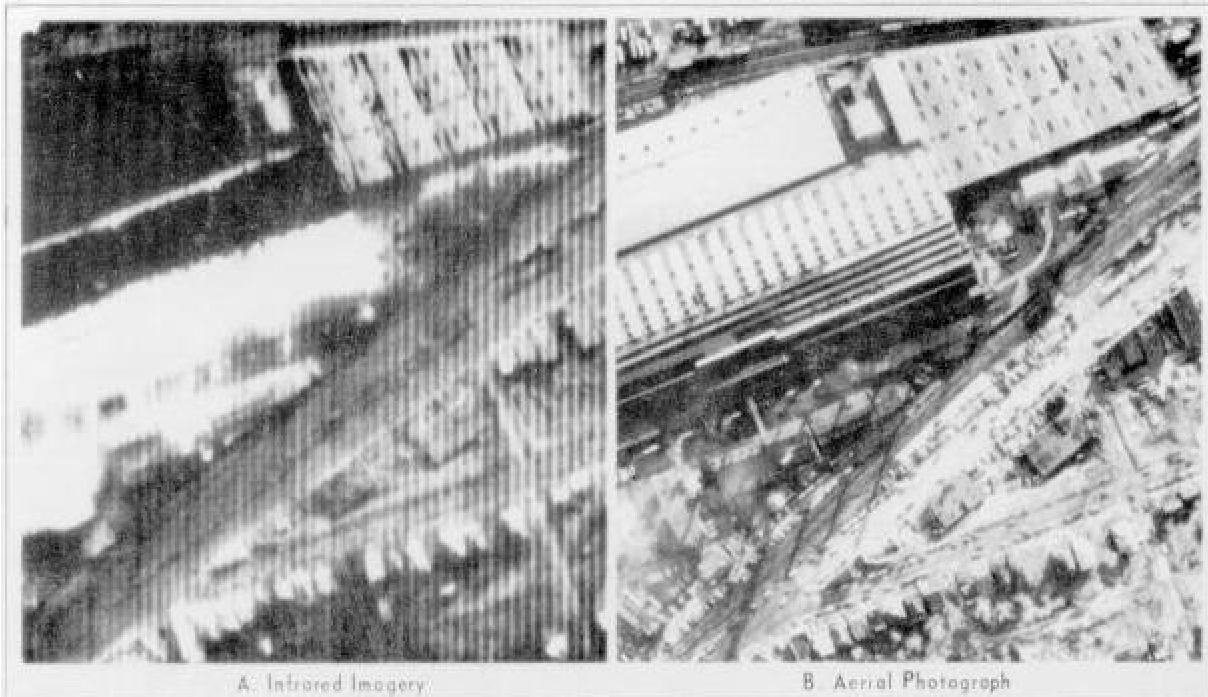


Figure 1-10. Comparison of IR with Photograph.

8. IR mensurations. The scaling and measurements of IR imagery are similar to vertical photography, using the formula ground distance (GD) = photo distance (PD) x denominator of the photo representative fraction (DPRF). Refer to subcourse IT 0644, Vertical Photogrammetry, for additional studies.

NOTE: Due to the scan technique and the emissivity factor of different objects on the ground, the measurement will not be 100 percent accurate.

PART C: INFRARED MISSION REQUESTING

1. Three different air reconnaissance request formats are used by US forces for IR R&S missions.

2. Joint Tactical Air R&S Request Form (Figure 1-11) is used by mission requesters. Specific information as to how to complete this form can be obtained by consulting IT 0661, R&S Managing, Requesting, Monitoring, and Communications.

JOINT TACTICAL AIR RECONNAISSANCE SURVEILLANCE REQUEST FORM

L	REQUEST NO. 5/Y/099 · PREPLANNED: IMMEDIATE · PRECEDENCE ____ · PRIORITY ____ · PRIORITY 2	FROM: 5 INF DIV TO: IV CORPS
M	TYPE RECON REQUESTED: 1. TYPE MISSION A. VISUAL B. IMAGERY C. WX 2. TYPE COVERAGE A. STRIP/LOC B. PINPOINT C. AREA D. AFLOAT D. OTHER *3. SENSOR A. OPTICAL B. IR C. SLAR D. LASER *4. TYPE PHOTO A. VERT B. OBLIQUE C. PAN D. STEREO *5. TYPE FILM A. B&W B. COLOR C. IR D. CAMFLG DET	APPROVED DISAPPROVED BY/REASON SENT TIME · BY
N	MAP REFERENCE: PRODUCER 1. AMS 2. ACIC/DMAAC 3. NAVOCEANO 4. OTHER (SPECIFY) ____ SERIES 1501 · SHEET NH12-2 · EDITION 2 · DATE 1970	RECEIVED TIME · BY CHECKED BY
O	TARGET COORDINATES AND DESCRIPTION: A. UTM/LAT - LONG 12RWL474138-545110-520050-470102 B. OTHER ____ C. TARGET DESCRIPTION: 1. AIRFIELD ____ 10. TERRAIN RECONNAISSANCE ____ 2. MISSILE SYSTEMS ____ 11. COASTAL STRIP ____ 3. ELECTRONIC INSTALLATIONS ____ 12. BRIDGES ____ 4. BARRACKS/CAMPS/HEADQUARTERS ____ 13. WATER CONTROL FACILITIES ____ 5. STORAGE AND REPAIR FACILITIES ____ 14. PORTS/HARBORS ____ 6. MILITARY ACTIVITY ____ 15. RAIL FACILITIES ____ 7. RIVER CROSSINGS/FERRIES ____ 16. INDUSTRIAL INSTALLATIONS ____ 8. SHIPPING ____ 17. ELECTRIC POWER INSTALLATIONS ____ 9. ROUTE RECONNAISSANCE ____	ACKNOWLEDGED BDE REGT DIV CORP OTHER COORDINATION RCVD DTG
P	PRIORITY INTELLIGENCE REQUIREMENTS (PIR): IS THE ENEMY DUG IN ALONG THE FLOT	BY (G-2) (AIO)
Q	* ACCEPTABLE PHOTO SCALE/SCALE LIMITS: 1:5,000	COORDINATED
R	REPORTS AND NUMBERS OF PRINTS OR PLOTS REQUIRED: 1. REPORTS A. INFLTREP (CS/FREQ) N3D/68.10 B. MISREP C. RECCEXREP D. RADAREXREP E. IPIR F. SUPIR 2. PRODUCTS (QUANTITY) A. PRINTS B. DUPOS C. NEG D. PLOT	FSE AIR DEF AVN NGF
S	DELIVERY ADDRESS: 1. UNIT ADDRESS: CDR, 5 INF DIV/TSO/FLD LOC *2. COORDS FOR AIRDROP ____ *3. CS/FREQ ____	NOTIFIED MIBARS II
T	DATE/TIME FACTORS: 1. DATE DESIRED 3 AUG 89 *2. TOT (IF APPLICABLE) 0500-0530Z 3. DNLV 03 0700Z AUG 89 4. PRIOR COVERAGE ACCEPTABLE (DAYS PRIOR) ND	BY · DTG REQUESTING UNIT NOTIFIED BY DTG
U	REMARKS/SPECIAL INSTRUCTIONS: *1. TARGET AREA CONTROL: CS FREQ/ORBIT POINT 9TH TAF AIR CONTROL 2. INFLIGHT RPT CS/FREQ N3D/68.10 3. RUN IN HEADING FOR AIRDROP 4. OTHER	AIR ACTION RCVD AT DTG BY

AIR MISSION DATA

V	1. MISSION NUMBER	2. CS B5V/31.15	3. TYPE ACFT	4. EST/ACT TAKEOFF	ACCEPT
	5. EST TOT	6. CONT PT/RDV (COORD/NAV AID)	7. INITIAL CONTACT	8. FINAL CONT (TACP/FAC) CS FREQ	REFUSE
	9. RESTRICTIVE FIRE/AIR PLAN SEE BLOCK V	*10. TGT DESCRIPTION		*11. TGT COORD/ELEV	REASON

FIREPLAN

W	1. RESTRICTIVE FIRE/AIR PLAN A IS NOT B NO	2. IN EFFECT A (FROM TIME) B (TO TIME)	
	3. LOCATION A ____ (FROM COORDINATES) B ____ (TO COORDINATES)	4. WIDTH (METERS)	5. ALTITUDE/VERTEX A ____ (MAXIMUM/VERTEX) B ____ (MINIMUM)

Figure 1-11.

3. A standard air reconnaissance request/task message is also used by certain units (Figure 1-12) in accordance with their standing operating procedure (SOP). Message precedence and security classification are determined by the requester. Letters A through K have a special significance for tactical air units. Paragraphs L, N, 0, P, S, and T must always be completed by the requester; other paragraphs only as appropriate.

CLASSIFICATION UNCLASSIFIED	REQUESTOR CDR V CORPS; DTG Ø81ØØ9Z JUN 85
PRECEDENCE ACTION OO INFO PP	INTERNAL COORDINATION G2 G3
FROM V CORPS COMM	INFO CENTAG
TO SEMBACH COMM	NORTHAG
	SIC
NOT FOR TRANSMISSION L ORIGINATOR SERIAL NO	L AIR RECCE REQUEST AIR RECCE TASK NO 2V3Ø1
M-1 TYPE OF SENSOR	M-1 ■ PHOTO [B] ELECTRONIC [C] SLAR ■ IR [E] BEST SUITABLE
M-2 TECHNIQUE	M-2 ■ VERTICAL [B] OBLIQUE [C] PANORAMIC [D] BEST POSSIBLE
N MAP SERIES SHEET NO AND EDITION NO	N M745, L-6126
O 1 TARGET LOCATION	O 1- TGT1: 32UNB123123, TGT2: 32UNB456456
O 2 TARGET DESCRIPTION	O 2- TGT1: CP, TGT 2: PINPOINT
P OBJECT AND RESULTS DESIRED (TARGET CATEGORY)	P TGT1: CAT Ø4D, TGT 2: CAT Ø6B
Q PHOTO SCALE	Q 1:5ØØØ OR [X] BEST POSSIBLE
R NO PRINTS PLOTS RPTS	R 1x RECCEXREP 1x PRINT EA SIGNIFICANT SIGHTING
S DELIVERY ADDRESS DATE TIME REQ	S CDR, V CORPS G-2-AIR ATTN: MAJ SMITH PRINTS REQ'D AT END EX
T LATEST ACCEPTABLE DATE TIME FOR DELIVERY	T-NLT 25 163ØZ JUN 85
U SPECIAL INSTRUCTIONS U 1 TOT	U 1- 1Ø11ØØ-13ØØZ JUN 85
U 2 PRIORITY	U 2- [ ] PRI-1 [X] PRI-2 [ ] PRI-3
U 3 TARGET SECURITY CLASS	U 3- UNCLASSIFIED
U 4 REMARKS	U 4- CONTACT FAC CALL SIGN: HONEY BEE ON TAD 682/BACK-UP 683 PRIOR TO ENTRY INTO TGT AREA FOR ADDITIONAL TGT INFO. INFLIGHT REPORT REQUESTED
V TASKING INSTRUCTIONS	
COPIES TO: COMM CTR, CURRENT OPS, INT, OTHER; ARMY, ATTACK, RECCE, EW	RCVD DTG Z; INITIALS; DRAFTER TEL NO; TRAN DTG; INITIALS; RELEASER TEL NO

Figure 1-12. Air Reconnaissance Request/Task Message.

4. Joint tactical surveillance request (JTACSURVREQ) form is used to give specific information needs to collection managers and desired reports. This form is used by US units only. Item 9 within the form is reserved for the mission type and item 10 for the type coverage (Figure 1-13).

JOINT MESSAGE FORM							SECURITY CLASSIFICATION					BOOK	MESSAGE HANDLING INSTRUCTIONS
PAGE	DTG/RELEASER TIME			PRECEDENCE			CLASS	SPECAT	LMF	CIC	ORIG. MSG IDENT		
OF	DATE TIME	MONTH	YR	ACT	INFO								

```
1  EXER/BOLD PUSH 85/UMPIRES ONLY//
2  OPER/YELLOWSTONE/IICORPS16Ø2/JELLY BEAN/APPLE PIE//
3  MSGID/JTACSURVREQ/II CORPS/25Ø9ØØ3/SEP/AMP/2//
4  REF/A/JTACSURVREQ/II CORPS/2516ØØZSEP85/25Ø9ØØ2/NOTAL/ABC//
   REQDATA/236/PRY:2/DATEDES:85Ø925/LTIOV:85Ø92713ØØZ/IMAGE/AREACOV
          5     6          7                   8          9      10
   /TOT:163ØZ/DPRIOROK:2/IR/IMQ:T/CM:C/ VT/M261HILLSBURG4284/
          11         12   13    14    15  16         17          18
19 /82D ABN DIV//
   TRCPLOT/32VMN123123/RAD:2KM//
                 20        21
22 TGTCOD/4ABEFGH//
23 HEADING/REPORTS//
   9RECONRQ
   /RPTREQ              /RECPD /QTY
   /IIR                 /DUPOS/  2
   /IIR                 /NEG  /  1
   /IIR                 /PRINT/  2//
             24            25    26
   9INFLTRF
   /CALLSIGN          /R-FREQ    /EFF-FM  /EFF-TO
   /R2D               /    31.5MHZ/2607ØØZ/2711ØØZ
   /R2D2              /   15Ø.3MHZ/26Ø83ØZ/27Ø83ØZ
   /2X4               /    74.9MHZ/2611ØØZ/27233ØZ//
           27               28         29      30
31 HEADING/AIR DROP INFORMATION//
   REQDATE/82D ABN DIV/32VMN1432413/RNHDG:Ø45T//
                  32          33         34
35 DECL/OADR//
```

DRAFTER NAME, TITLE, OFFICE SYMBOL, PHONE	SPECIAL INSTRUCTIONS		DISTR
RELEASER — NAME, TITLE, OFFICE SYMBOL AND PHONE			
SIGNATURE	SECURITY CLASSIFICATION	DATE TIME GROUP	

JRF 1 0002 01 12 MAY 84

Figure 1-13. JTACSURVREQ Joint Message Form.

PART D: INFRARED MISSION REPORTING

1. In reporting IR mission results the same formats are used as for reporting mission results from aerial photography or SLAR.

2. In-flight report (INFLIGHTREP). The OV-1D Mohawk aircraft employed by the US National Guard has in-flight readout devices in the cockpit; the RF-4C, F-4E, and F-111F aircraft uses the AN/AVQ-26 Pave Tack forward-looking IR sensor. It requested, the air crew of these aircraft can transmit mission results over a secure voice radio directly to the requester's tactical air control party (TACP) or collection management and dissemination (CM&D) mission manager. However, the RF-4C using the AN/AAD-5 IR reconnaissance set does not have cockpit readout capability. There are two different INFLIGHTREP formats, the North Atlantic Treaty Organization (NATO) format is shown in Figure 1-14, and the US Message Text Format (USMTF) shown in Figure 1-15.

U N C L A S S I F I E D

INFLIGHTREP (always start of message)	INFLIGHTREP
AIR TASK/MISSION NUMBER/ORIGINATOR'S	2/G/321
A. LOCATION IDENTIFIER	A. KZ123456/
B. TIME ON TARGET/TIME OF SIGHTING (in ZULU time)	B. 1500Z/
C. RESULTS	C. 15 X HOT EMISSIONS/

U N C L A S S I F I E D

Figure 1-14. INFLIGHTREP Format and Report Example-NATO.

NOTE: This report is not an image analysis report; however, the IA will use this report when available. Furthermore, classification is printed in larger than normal lettering at top and bottom when recording it.

INFLIGHTREP VOICE TEMPLATE Pg 1 of 1

D3964 THIS IS BLUE JAY INFLIGHTREP OVER
addressee originator

addressee answers, then originator responds — THIS IS BLUE JAY
addressee originator

FLASH **IMMEDIATE** PRIORITY ROUTINE (Underline and transmit the precedence of this message.)

TOP SECRET SECRET CONFIDENTIAL **UNCLASSIFIED** (Underline and transmit the security classification of this message.)

INFLIGHTREP

LINE 1 (or) CALLSIGN BLUE JAY (Call Sign Identifier) 1

LINE 2 (or) MISSION A367A (Mission Number) 2

LINE 3 (or) REQUEST A1372 (Request Number) 3

LINE 4 (or) LOCATION MN349732 (Location of Target or Sigting in Bearing and Range, GEOREF, LAT/LONG, UTM, Target number or Name) 4

LINE 5 (or) TIME 0900Z (Hour-Minute-Zone of Attack or Observation) 5

LINE 6 (or) RESULTS 12 TANKS DESTROYED. REATTACK (Results of Mission, Recommendation for attack/reattack if necessary) 6

LINE 7 (or) SIGHTING 35 T-72 TANKS ADVANCING IN LINE. (Description of Sighting or Target.) 7

LINE 8 (or) NARRATIVE HEADING WEST SOUTH WEST AT 35 KILOMETERS PER HOUR. 8

LINE 9 (or) TIME 0803Z (Message Hour-Minute-Zone when required) 9

LINE 10 (or) AUTHENTICATION IS WP (Message Authentication IAW JTF procedures) 10

OVER

INFLIGHTREP VOICE TEMPLATE Pg 1 of 1

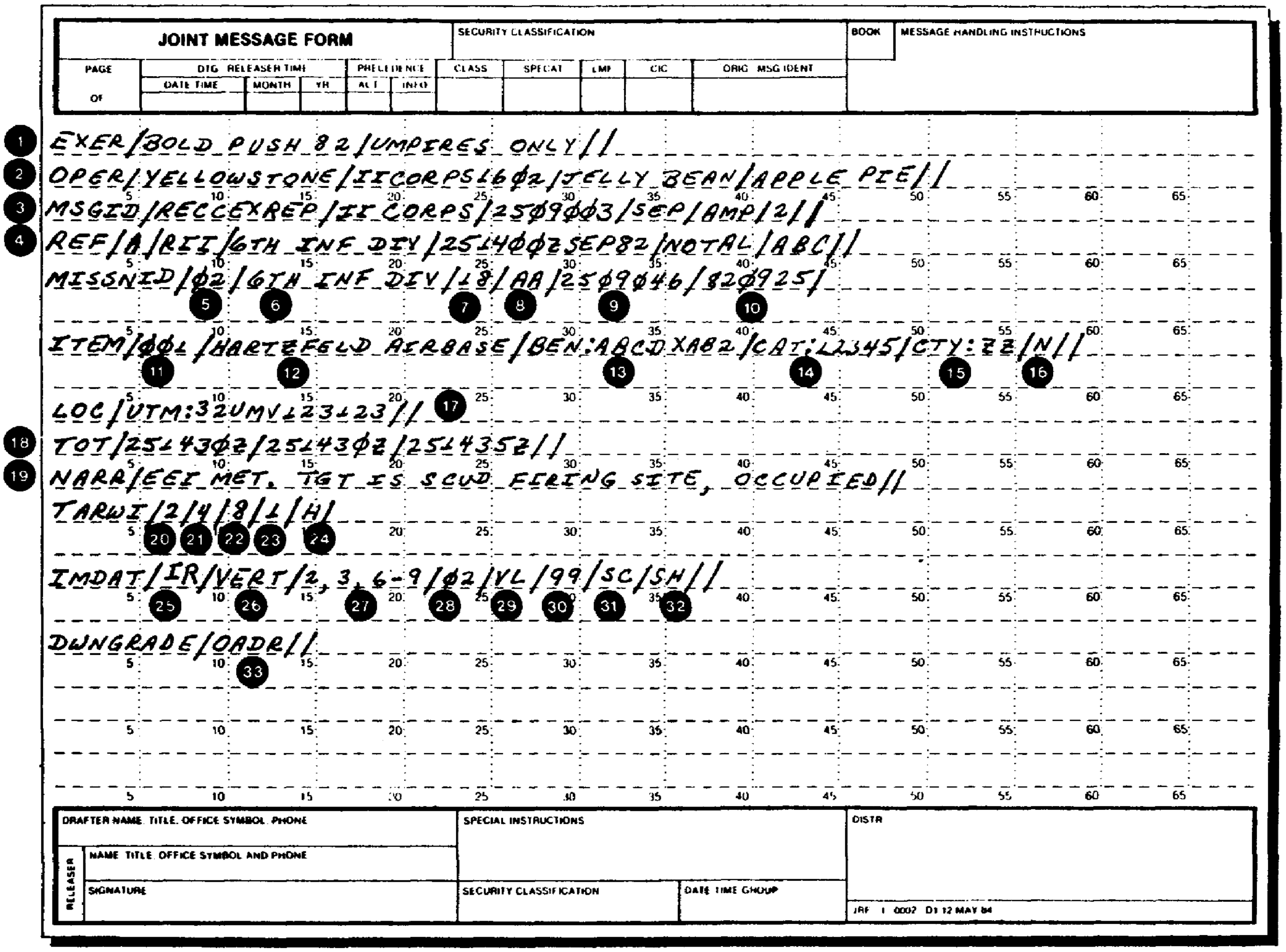
Figure 1-15. INFLIGHTREP Voice Template--USMTF.

3. Reconnaissance exploitation report (RECCEXREP) informs the requester of the results obtained from a reconnaissance mission. The imagery must be analyzed by an IA and the report prepared and delivered to the dedicated transmission point within 45 minutes after engine shutdown. if further analysis of the imagery reveals additional information, a second RECCEXREP must be immediately transmitted. Sightings from the pilot and the air crew previously reported in the INFLIGHTREP and/or derived from the debriefing must also be included. The following standard format is used for NATO missions as shown in Figure 1-16. The second RECCEXREP is governed by the USMTF format (Figures 1-17 and 1-18).

NATO CLASSIFICATION	NATO UNCLASSIFIED
RECCEXREP (always start of message)	RECCEXREP
AIR TASK/MISSION NUMBER AND ORIGINATOR'S SERIAL NUMBER	2/T/123
A. LOCATION IDENTIFIER	A. 12XLC751342/
B. TIME ON TARGET	B. 231600Z/
C1. RESULTS	C1. CAT 06/ 1. MECH INF/ 2. STATIC/OFF RD IN EDGE OF TREES FACING RD/
C2. FURTHER REPORT MAY FOLLOW YES/NO	C2. YES/
D1. OTHER INFORMATION	D1. CONC AAA FROM AREA 2 KM S OF TGT/
D2. WEATHER	D2. COURSE/
D3. IMAGERY CONFIRMED YES/NO	D3. YES/
E. SENSOR TYPE & EXPOSURE NUMBERS	E. IR
F. QUALITY OF IMAGERY (NIIRS)	F. 3/
G. PERCENTAGE OF COVER	G. 100/
END OF MESSAGE	EOM

Figure 1-16. RECCEXREP Format and Example--NATO.

NOTE: Line F (Quality of Imagery) is normally assigned a national imagery interpretability rating scale (NIIRS). See Subcourse IT 0687, Imagery Analysis Reports.



JOINT MESSAGE FORM

SECURITY CLASSIFICATION | BOOK | MESSAGE HANDLING INSTRUCTIONS

PAGE OF | DTG RELEASER TIME (DATE TIME, MONTH, YR) | PRECEDENCE (ACT, INFO) | CLASS | SPECAT | LMF | CIC | ORIG MSG IDENT

EXER/BOLD PUSH 82/UMPIRES ONLY//
OPER/YELLOWSTONE/IICORPS16Ø2/JELLY BEAN/APPLE PIE//
MSGID/RECCEXREP/II CORPS/25Ø9ØØ3/SEP/AMP/2//
REF/A/RII/6TH INF DIV/2514ØØZSEP82/NOTAL/ABC//
MISSNID/Ø2/6TH INF DIV/18/AA/25Ø9Ø46/82Ø925/
ITEM/ØØ1/HARTEFELD AIRBASE/BEN:ABCDXA82/CAT:12345/CTY:ZZ/N//
LOC/UTM:32UMV123123//
TOT/2514 3ØZ/25143ØZ/251435Z//
NARR/EEI MET. TGT IS SCUD FIRING SITE, OCCUPIED//
TARWI/2/4/8/1/H/
IMDAT/IR/VERT/2,3,6-9/Ø2/VL/99/SC/SH//
DWNGRADE/OADR//

DRAFTER NAME, TITLE, OFFICE SYMBOL, PHONE | SPECIAL INSTRUCTIONS | DISTR

RELEASER: NAME, TITLE, OFFICE SYMBOL AND PHONE | SIGNATURE | SECURITY CLASSIFICATION | DATE TIME GROUP

JRF 1 0002 D1 12 MAY 84

Figure 1-17. RECCEXREP Joint Message Form--USMTF.

RECCEXREP VOICE TEMPLATE Pg 1 of 2

F6 THIS IS F6Z RECCEXREP OVER
addressee originator

addressee answers, then THIS IS F6Z
originator responds addressee originator

FLASH IMMEDIATE PRIORITY ROUTINE (Underline and transmit the procedure of this message.)

TOP SECRET SECRET CONFIDENTIAL (Underline and transmit the security classification of this message.)

CLEAR UNCLASSIFIED

RECCEXREP

LINE 1 (or) SERIAL	25Ø9ØØ3	(Report Serial Number)
LINE 2 (or) REQUEST	18	(Requestor Identification and Serial Number)
LINE 3 (or) PROJECT	AA	(Project Identifier Code)
LINE 4 (or) MISSION	25Ø9Ø46	(Mission Number)
LINE 5 (or) DATE	89Ø925	(Mission Date, Year, Month, Day)
LINE 6 (or) ITEM	1	(Item Number)*
LINE 7 (or) NAME	HARZFELD AIRBASE	(Target Name or Description)
LINE 8 (or) Number	ABCD X ABC	(BE Number, IBE Number, ABE Number, or TBE Number)
LINE 9 (or) LOCATION	32UMV123456	(Location of Sighting in LAT/LONG or UTM)
LINE 10 (or) TIME	143ØZ	(Time of Sighting, Day-Hour-Minute-Zone)
LINE 11 (or) STATUS	OCCUPIED	(Status of Activity/Target)
LINE 12 (or) COUNT	1	Count of OB Items)
LINE 13 (or) TYPE	SSM	Type of OB Items)

When additional targets in a single message use the same line numbers when repeating the segment of lines ITEM through Line 7. NAME ....; Line 6. ITEM....; Line 7.

RECCEXREP VOICE TEMPLATE Pg 1 of 2.

Figure 1-18. RECCEXREP Voice Template--USMTF.

RECCEXREP VOICE TEMPLATE Pg 2 of 2

LINE 14 (or) NARRATIVE OCCUPIED SCUD FIRING SITE

LINE 15 (or) TIME 1445Z (Message Hour-Minute-Zone when required)

LINE 16 (or) AUTHENTICATION IS CF (Message Authentication IAW JTF procedures)

OVER

RECCEXREP VOICE TEMPLATE Pg 2 of 2

Figure 1-18. RECCEXREP Voice Template--USMTF (Concluded).

4. Initial programmed interpretation report (IPIR) and supplemental programmed interpretation report (SUPIR) is used in NATO reporting in the general version or automated data processing system (ADPS) format. IPIRs and SUPIRs are not normally requested for IR missions. For further information see Subcourse IT 0687, Imagery Interpretation Reports.

5. Imagery interpretation report (IIR) is used in the USMTF system to report IPIRs and SUPIRs. Again, an IIR is seldom requested for an IR mission. For additional information consult DA Pam 25-7.

LESSON ONE

PRACTICE EXERCISE

The following items will test your grasp of the material covered in this lesson. There is only correct answer to each item. When you have completed the exercise, check your answers with the answer key that follows. If you answer any item incorrectly, study again that part of the lesson which contains the portion involved.

NOTE: Replace page 35 with photo page 35 attached in back of the subcourse booklet for better viewing.

1. At certain times during the day, particularly around sunrise or sunset, objects on the ground exhibit peculiar properties. In fact some objects seem to "disappear." What is this phenomenon called?

   A. Crossover time.

   B. Blackbody effect.

   C. Ghosting.

   D. Atmospheric attenuation.

2. Atmospheric attenuation is the effect of all the following EXCEPT:

   A. Vapor gases and dust in the atmosphere.

   B. Fog.

   C. Rain.

   D. Cosmic radiation.

3. What type of sensor is the AN/AAS-24?

   A. Radar.

   B. Photo.

   C. Active.

   D. Passive.

4. What is the atmospheric window?

   A. A region where most IR energy is blocked.

   B. IR shadow.

   C. A region of high transmission of IR energy.

   D. A region of low transmission of IR energy.

5. On positive IR imagery, how will a warm target appear in tone against a cold background?

   A. Dark.

   B. Light.

   C. Sepia.

6. What is the primary source of energy on the earth?

   A. The stars.

   B. The sun.

   C. Attenuation.

   D. The moon.

7. To interpret IR imagery, you may often need maps or ground data in order to employ which of the five "Ss"?

   A. Shadow.

   B. Surroundings.

   C. Size.

   D. Shape.

8. Which part of the Joint Tactical Air R&S Request form must be marked to indicate the IR imagery requested?

   A. O.

   B. P.

   C. M.

   D. N.

9. At what temperature does molecular activity cease?

   A. -460° F.

   B. 0° C.

   C. 32° F.

   D. 212° F.

10. On negative IR imagery, how would a large body of water appear in tone if the mission were flown at 0200 hours?

    A. Dark.

    B. Light.

    C. Light gray.

    D. Colorless.

Refer to Figure 1-19, positive night IR photo. Match the objects in questions 11 through 15 with the annotations in column A.

<u>Questions</u>	<u>Annotations</u>
11. Body of water.	A.
12. Asphalt pavement.	B.
13. Grass.	C.
14. Trees.	D.
15. Metal surfaces.	E.

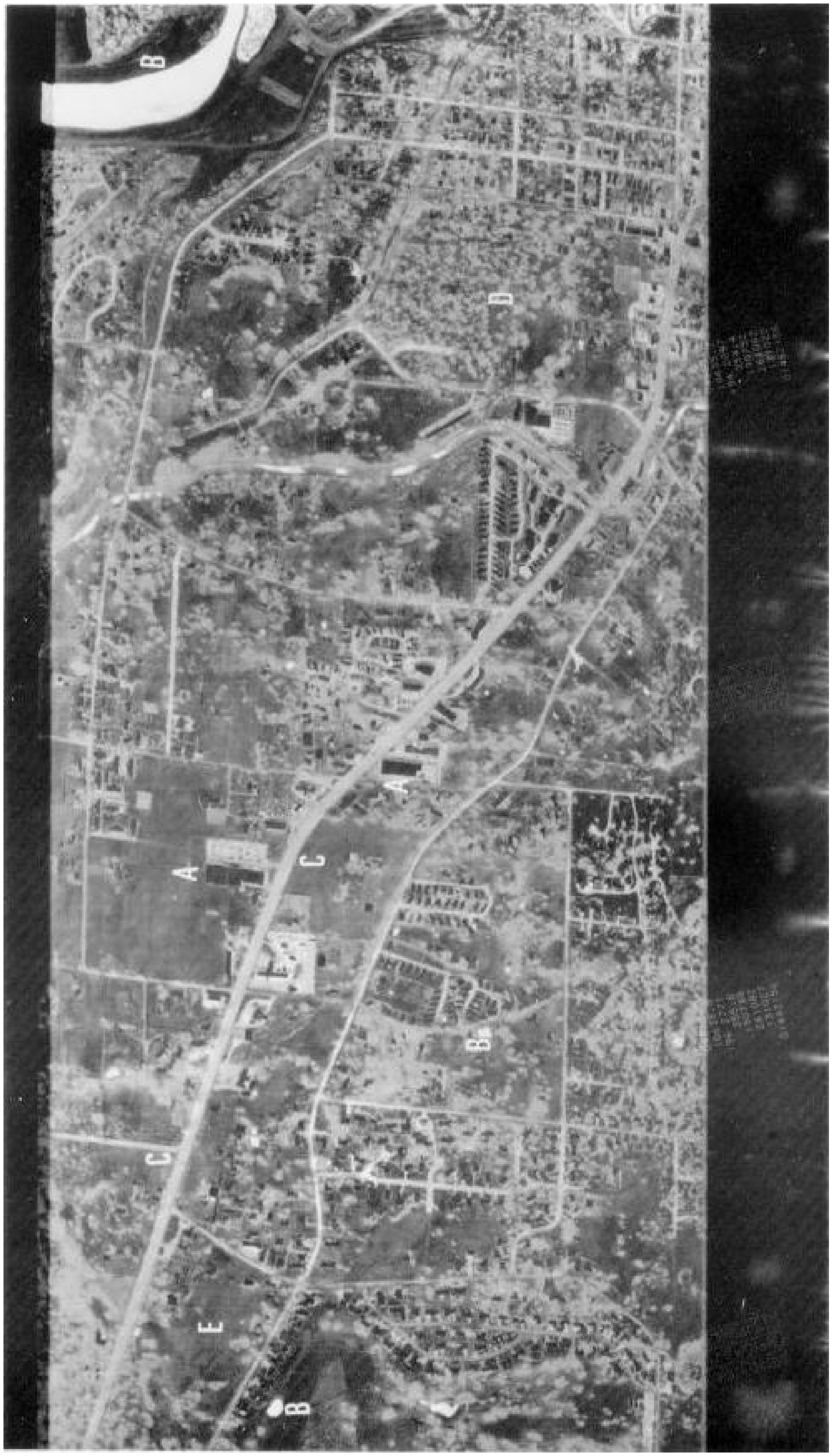


Figure 1-19. Positive Night IR Photo.

LESSON ONE

PRACTICE EXERCISE

ANSWER KEY AND FEEDBACK

Item	Correct Answer and Feedback
1.	A. Crossover time is in the early morning and early evening when land and water will have the same IR output (page 8, para 11b(2)).
2.	D. Excluding cosmic radiation, rain, vapor gases and dust, and fog will effect atmospheric attenuation (page 6, para 11a).
3.	D. The AN/AAS-24 is a passive sensor because it does not emit any signals (pages 5/6, para 10).
4.	C. Regions of high transmission of IR energy are atmosphere windows (page 6, para 11a).
5.	B. On positive IR imagery, a hot target will be light in tone to a cold dark background (page 15, para 1, NOTE).
6.	B. The primary source of IR energy on the earth is the sun (page 4, para 6).
7.	B. You use maps and ground data to identify the surroundings of extremely hot targets (page 17, para 2c).
8.	C. Line M, TYPE RECON REQUESTED, is used to show that IR imagery is requested on the Joint Tactical Air R&S Request Form (page 23, fig 1-11).
9.	A. -460° Fahrenheit is the temperature where all molecular activity ceases (page 2, para 3).
10.	A. A large body of water will have a dark tone on negative IR imagery taken at 0200 due to its high emissivity and good heat transfer proprieties (page 20, para 4f(6)).
11.	B. Water will range in tone from light gray to white on positive night IR imagery (pages 15/20, paras 1, NOTE/4f(6)).
12.	C. Asphalt pavement appears light gray to white (pages 15/20, paras 1, NOTE/4f (2)).
13.	E. Grass appears light gray to dark gray (pages 15/20, paras 1, NOTE/4f(4)).

Item	Correct Answer and Feedback
14.	D. Trees appear light gray to white (pages 15/20, paras 1, NOTE/ 4f(5)).
15.	A. Metal surfaces (metal roof tops) will appear black on positive night IR imagery (pages 15/20, paras 1, NOTE/4f(1)).

LESSON TWO

INFRARED IMAGERY PLOTTING

MOS MANUAL TASKS: 301-338-1609
301-338-3701

OVERVIEW

TASK DESCRIPTION:

In this lesson you will learn to describe the basic plotting components, peculiarities, and methods of IR imagery.

LEARNING OBJECTIVE:

ACTIONS:	Describe the components, peculiarities, and methods required to plot IR imagery.
CONDITIONS:	You will be given access to extracts from STP-34-96D1-SM and TC 34-55.
STANDARDS:	IR imagery plotting will be IAW STP-34-96D1-SM, and TC 34-55.
REFERENCES:	The material contained in this lesson was derived from the following publications: STP-34-96D1-SM. TC 34-55.

INTRODUCTION

An imagery plot is a record of the ground area covered by an airborne sensor. The plot may be prepared directly onto a map or on a transparent overlay keyed to a map. Plots are essential to identify, locate, and control aerial imagery. Plotting IR is very similar to plotting conventional vertical photography with a few differences.

PART A: BASIC PLOTTING COMPONENTS AND PECULIARITIES

1. Basic plotting components. In preparing the plot the IA must keep in mind time limitations, the use to be made of the plot, and local SOP. In order for an overlay to be read and understood by others, it must be prepared IAW recognized standards of overlay construction:

a. Security classification is located at top and bottom center of the overlay paper in larger than any other lettering and at the bottom of the title block.

b. Location and orientation marks. All overlay plots should be keyed accurately to their base map at the top right and bottom left by transposing grid lines and indicating the 100,000 meter (m) prefix and grid numbers.

c. Title block information can be obtained from a number of sources to include the data blocks on the imagery, a pilot's trace, titling data on the film head or tail, or on the map.

2. Normally, the title block consists of information required by local SOP. The following example illustrates the minimum data required for a plot of an IR mission. This information is preceded by the title "INTERPRETATION PLOT" (Figure 2-1).

INTERPRETATION PLOT

MAP REFERENCE:	
SHEET NAME	FORT HUACHUCA
SHEET NO	3947 III
MAP SERIES NO	V798
SCALE	1:50,000
AREA	ARIZONA
IR DATA:	
MISSION	654-01
ORGANIZATION	SEMAID
REMARKS	NONE
SYSTEM/FOCAL LENGTH	AN/AAS-24/1.2 INCHES
RADAR ALTITUDE	2,000 FT AGL
DATE FLOWN	07 JAN 90
TIME OVER TARGET	2200Z
GROUND CONDITION	CLEAR
CLOUD COVER	30 PERCENT
NIIRS	3
PREPARED BY:	
ORGANIZATION	YOUR UNIT
RANK/NAME	YOUR RANK/NAME
DATE	TODAY'S DATE
UNCLASSIFIED	

Figure 2-1.

NOTE: For quality, use the given NI IRS specification.

3. AN/AYA-10 automatic data annotation system (ADAS). The data block on IR imagery is produced by the AN/AYA-10 ADAS. This data block appears every 2 inches on IR imagery in either binary code or numbered text (Figure 2-2).

Line 1 - 05510.5	=	UTM Northing Coordinate
Line 2 - 32489.5	=	UTM Easting Coordinate
Line 3 - 141 1013	=	Airspeed (141) Radar Altitude (1013)
Line 4 - 253.0	=	Magnetic Heading
Line 5 - 214038	=	Hours (21) Minutes (40) Seconds (38)
Line 6 - 04250589	=	Filter Position (04) Day (25) Month (05) Year (89)
Line 7 - 017007	=	Flying Unit Identifier (017007)
Line 8 - 07922230	=	Frame (0792) Mission No. (2230)

Figure 2-2. IR Data Block.

a. Extracting the universal transverse mercator (UTM) coordinates from the data block is simple. Refer to Figure 2-2. Read the first three digits of line 2 (324). Then, read the first three digits of line 1 (055); this will give you the six-digit UTM coordinate 324055.

b. In determining the location on the imagery, proceed in the Following manner:

Step 1: Locate the center of the imagery just above the data block.

Step 2: Mark off 7 inches opposite the aircraft's flight direction. You are now in the general vicinity of the desired UTM coordinate.

4. <u>Plotting peculiarities of the AN/AAS-24 IR</u> mapping system and the AN/AAD-5 IR reconnaissance set. The imagery produced by these IR systems is a continuous strip which is normally presented by two parallel lines. There are a few peculiarities of IR imagery you should be aware of:

a. Altitude change. A change in the altitude of the aircraft will effect the size of the area coverage.

(1) An increase in the altitude of the aircraft will cause the sensor to cover more area on the ground and result in an increase in the width of your plot (Figure 2-3).

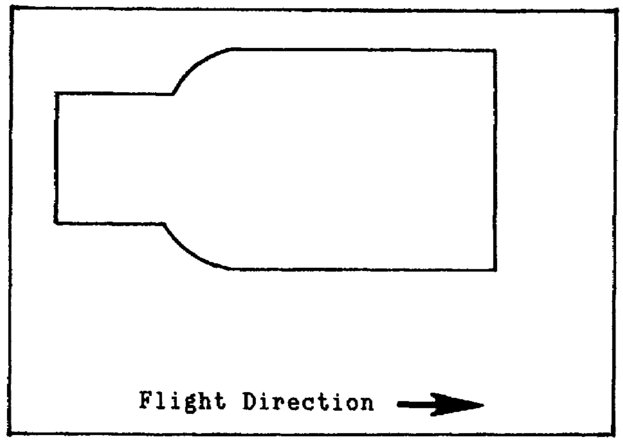


Figure 2-3. Increase in Altitude.

(2) A decrease in aircraft altitude will cause the sensor to cover less area on the ground which results in a decrease in the width of your plot.

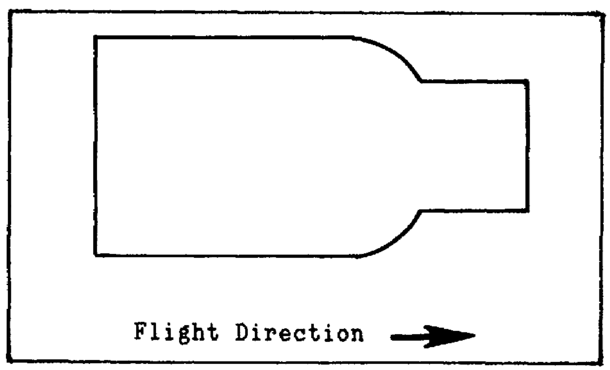


Figure 2-4. Decrease in Altitude.

b. Aircraft Turns. An aircraft making a turn along the flight path will cause the plot to bulge since more area is covered on one side of the flight path than the other side (Figure 2-5). Caution must be utilized when plotting IR imagery because turns <u>will not be</u> obvious.

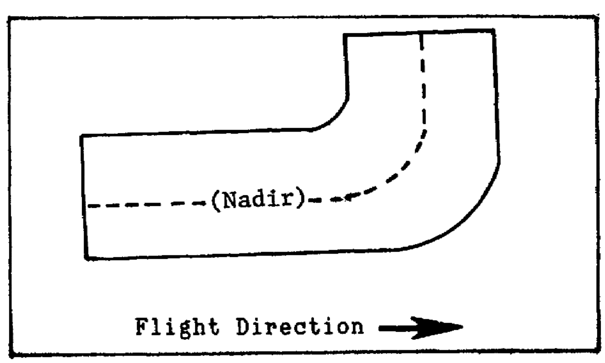


Figure 2-5. Aircraft Turn.

5. Plotting peculiarities of the AN/AVQ-26 pave tack reconnaissance sensor. To plot pave tack imagery is almost impossible. The imagery produced by the pave tack system is a continuous strip with no break in the flow of the imagery. The moveable sensor will produce imagery from every direction from forward or rearward oblique, to left or right high or low oblique, to panoramic to vertical.

PART B: INFRARED PLOTTING METHODS

1. There are two methods that can be used when plotting an IR mission.

a. Plotting method 1, plotting identifiable features. Identify features on the extreme edges of the imagery that appear on the map. Make small tick marks at these locations on the overlay paper over the map. Then, using a straightedge or French curve, connect the tick marks and enclose the area covered by the IR imagery (Figure 2-6).

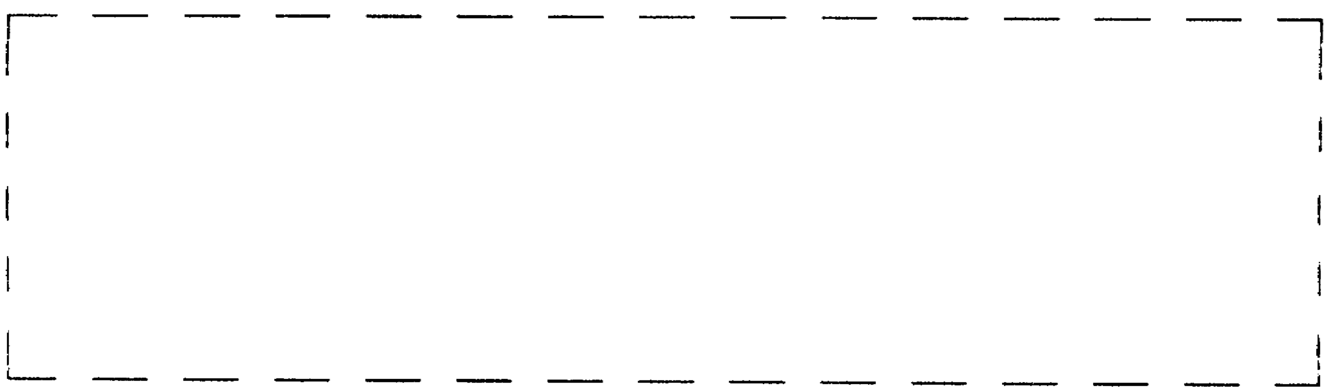


Figure 2-6. Tick Marks Representing Detail Found on both Map and Imagery.

b. Plotting method 2, mathematical computation from the nadir. When detail is lacking along the edges of the imagery, draw an imaginary line down the center of the imagery, which will represent the nadir or flight path directly below the aircraft. Next, compare details along the imaginary line to details on the map. Using the scan angle for each side of the nadir, plot the area covered by the mission (Figure 2-7).

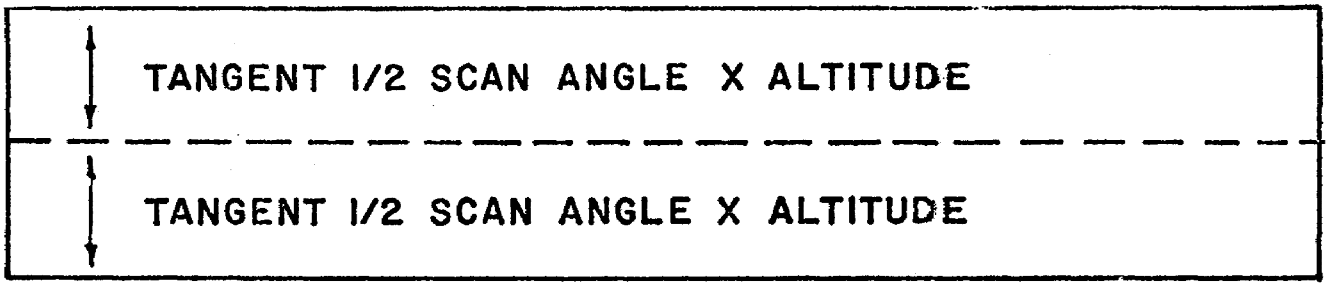


Figure 2-7. Tick Marks Representing
Matching Detail at Nadir.

NOTE: See Figure 1-4 for an explanation of the scan angle.

2. There are two ways to determine ground coverage vertical to the flight path. One way is that the altitude above ground level (AGL) or H-h in ft equals the approximate ground coverage in m. To obtain a more accurate measurement, multiply the tangent (Tan) value of one half the scan angle (∢) of the imagery. Your answer will give you ground coverage for <u>one half</u> of the imagery in ft or m, depending on the measurement you are using. For example, H-h = 2,000 ft and half the scan angle (∢) = 60°. You must first use the trigonometric functions (trig) table (Figure 2-8) to convert 60° to its Tan value, which is 1.7320. Next, you must multiply 2,000 x 1.7320 = 3,464 ft, which covers 1/2 a flight line width, multiplied by 2 = 6,928 ft; to obtain m, divide 6,928 by 3.281 and you have 2,112 m of total coverage. Using the following formula:

$$\text{Ground coverage} = \frac{\text{Tan } 60^\circ \times (H\text{-}h) \times 2}{3.281}$$

$$\text{Ground coverage} = \frac{1.7320 \times 2\,000 \text{ ft} \times 2}{3.281} = 2{,}112 \text{ m.}$$

NOTE: In most cases, missions will be flown straight and level. But, on occasion it may not be practical.

3. For additional information of trig functions, study subcourse IT 0684, panoramic photogrammetry.

NATURAL TRIGONOMETRIC FUNCTIONS

28°							29°						
M	Sine	Cosine	Tan.	Cotan.	Secant	Cosec.	Sine	Cosine	Tan.	Cotan.	Secant	Cosec.	M
0	0.46947	0.88295	0.53171	1.8807	1.1326	2.1300	0.48481	0.87462	0.55431	1.8040	1.1433	2.0627	60
1	.46973	.88281	.53208	.8794	.1327	.1289	.48506	.87448	.55469	.8028	.1435	.0616	59
2	.46998	.88267	.53245	.8781	.1329	.1277	.48532	.87434	.55507	.8016	.1437	.0605	58
3	.47024	.88254	.53283	.8768	.1331	.1266	.48557	.87420	.55545	.8003	.1439	.0594	57
4	.47050	.88240	.53320	.8754	.1333	.1254	.48583	.87405	.55583	.7991	.1441	.0583	56
5	0.47075	0.88226	0.53358	1.8741	1.1334	2.1242	0.48608	0.87391	0.55621	1.7979	1.1443	2.0573	55
6	.47101	.88213	.53395	.8728	.1336	.1231	.48633	.87377	.55659	.7966	.1445	.0562	54
7	.47127	.88199	.53432	.8715	.1338	.1219	.48659	.87363	.55697	.7954	.1446	.0551	53
8	.47152	.88185	.53470	.8702	.1340	.1208	.48684	.87349	.55735	.7942	.1448	.0540	52
9	.47178	.88171	.53507	.8689	.1341	.1196	.48710	.87335	.55774	.7930	.1450	.0530	51
10	0.47204	0.88158	0.53545	1.8676	1.1343	2.1185	0.48735	0.87320	0.55812	1.7917	1.1452	2.0519	50
11	.47229	.88144	.53582	.8663	.1345	.1173	.48760	.87306	.55850	.7905	.1454	.0508	49
12	.47255	.88130	.53619	.8650	.1347	.1162	.48786	.87292	.55888	.7893	.1456	.0498	48
13	.47281	.88117	.53657	.8637	.1349	.1150	.48811	.87278	.55926	.7881	.1458	.0487	47
14	.47306	.88103	.53694	.8624	.1350	.1139	.48837	.87264	.55964	.7868	.1459	.0476	46
15	0.47332	0.88089	0.53732	1.8611	1.1352	2.1127	0.48862	0.87250	0.56003	1.7856	1.1461	2.0466	45
16	.47357	.88075	.53769	.8598	.1354	.1116	.48887	.87235	.56041	.7844	.1463	.0455	44
17	.47383	.88061	.53807	.8585	.1356	.1104	.48913	.87221	.56079	.7832	.1465	.0444	43
18	.47409	.88048	.53844	.8572	.1357	.1093	.48938	.87207	.56117	.7820	.1467	.0434	42
19	.47434	.88034	.53882	.8559	.1359	.1082	.48964	.87193	.56156	.7808	.1469	.0423	41
20	0.47460	0.88020	0.53919	1.8546	1.1361	2.1070	0.48989	0.87178	0.56194	1.7795	1.1471	2.0413	40
21	.47486	.88006	.53957	.8533	.1363	.1059	.49014	.87164	.56232	.7783	.1473	.0402	39
22	.47511	.87992	.53995	.8520	.1365	.1048	.49040	.87150	.56270	.7771	.1474	.0392	38
23	.47537	.87979	.54032	.8507	.1366	.1036	.49065	.87136	.56309	.7759	.1476	.0381	37
24	.47562	.87965	.54070	.8495	.1368	.1025	.49090	.87121	.56347	.7747	.1478	.0370	36
25	0.47588	0.87951	0.54107	1.8482	1.1370	2.1014	0.49116	0.87107	0.56385	1.7735	1.1480	2.0360	35
26	.47613	.87937	.54145	.8469	.1372	.1002	.49141	.87093	.56424	.7723	.1482	.0349	34
27	.47639	.87923	.54183	.8456	.1373	.0991	.49166	.87078	.56462	.7711	.1484	.0339	33
28	.47665	.87909	.54220	.8443	.1375	.0980	.49192	.87064	.56500	.7699	.1486	.0329	32
29	.47690	.87895	.54258	.8430	.1377	.0969	.49217	.87050	.56539	.7687	.1488	.0318	31
30	0.47716	0.87882	0.54295	1.8418	1.1379	2.0957	0.49242	0.87035	0.56577	1.7675	1.1489	2.0308	30
31	.47741	.87868	.54333	.8405	.1381	.0946	.49268	.87021	.56616	.7663	.1491	.0297	29
32	.47767	.87854	.54371	.8392	.1382	.0935	.49293	.87007	.56654	.7651	.1493	.0287	28
33	.47792	.87840	.54409	.8379	.1384	.0924	.49318	.86992	.56692	.7639	.1495	.0276	27
34	.47818	.87826	.54446	.8367	.1386	.0912	.49343	.86978	.56731	.7627	.1497	.0266	26
35	0.47844	0.87812	0.54484	1.8354	1.1388	2.0901	0.49369	0.86964	0.56769	1.7615	1.1499	2.0256	25
36	.47869	.87798	.54522	.8341	.1390	.0890	.49394	.86949	.56808	.7603	.1501	.0245	24
37	.47895	.87784	.54559	.8329	.1391	.0879	.49419	.86935	.56846	.7591	.1503	.0235	23
38	.47920	.87770	.54597	.8316	.1393	.0868	.49445	.86921	.56885	.7579	.1505	.0224	22
39	.47946	.87756	.54635	.8303	.1395	.0857	.49470	.86906	.56923	.7567	.1507	.0214	21
40	0.47971	0.87742	0.54673	1.8291	1.1397	2.0846	0.49495	0.86892	0.56962	1.7555	1.1508	2.0204	20
41	.47997	.87728	.54711	.8278	.1399	.0835	.49521	.86877	.57000	.7544	.1510	.0194	19
42	.48022	.87715	.54748	.8265	.1401	.0824	.49546	.86863	.57039	.7532	.1512	.0183	18
43	.48048	.87701	.54786	.8253	.1402	.0812	.49571	.86849	.57077	.7520	.1514	.0173	17
44	.48073	.87687	.54824	.8240	.1404	.0801	.49596	.86834	.57116	.7508	.1516	.0163	16
45	0.48099	0.87673	0.54862	1.8227	1.1406	2.0790	0.49622	0.86820	0.57155	1.7496	1.1518	2.0152	15
46	.48124	.87659	.54900	.8215	.1408	.0779	.49647	.86805	.57193	.7484	.1520	.0142	14
47	.48150	.87645	.54937	.8202	.1410	.0768	.49672	.86791	.57232	.7473	.1522	.0132	13
48	.48175	.87631	.54975	.8190	.1411	.0757	.49697	.86776	.57270	.7461	.1524	.0122	12
49	.48201	.87617	.55013	.8177	.1413	.0746	.49723	.86762	.57309	.7449	.1526	.0111	11
50	0.48226	0.87603	0.55051	1.8165	1.1415	2.0735	0.49748	0.86748	0.57348	1.7437	1.1528	2.0101	10
51	.48252	.87588	.55089	.8152	.1417	.0725	.49773	.86733	.57386	.7426	.1530	.0091	9
52	.48277	.87574	.55127	.8140	.1419	.0714	.49798	.86719	.57425	.7414	.1531	.0081	8
53	.48303	.87560	.55165	.8127	.1421	.0703	.49823	.86704	.57464	.7402	.1533	.0071	7
54	.48328	.87546	.55203	.8115	.1422	.0692	.49849	.86690	.57502	.7390	.1535	.0061	6
55	0.48354	0.87532	0.55241	1.8102	1.1424	2.0681	0.49874	0.86675	0.57541	1.7379	1.1537	2.0050	5
56	.48379	.87518	.55279	.8090	.1426	.0670	.49899	.86661	.57580	.7367	.1539	.0040	4
57	.48405	.87504	.55317	.8078	.1428	.0659	.49924	.86646	.57619	.7355	.1541	.0030	3
58	.48430	.87490	.55355	.8065	.1430	.0648	.49950	.86632	.57657	.7344	.1543	.0020	2
59	.48455	.87476	.55393	.8053	.1432	.0637	.49975	.86617	.57696	.7332	.1545	.0010	1
60	0.48481	0.87462	0.55431	1.8040	1.1433	2.0627	0.50000	0.86603	0.57735	1.7320	1.1547	2.0000	0
M	Cosine	Sine	Cotan.	Tan.	Cosec.	Secant	Cosine	Sine	Cotan.	Tan.	Cosec.	Secant	M
						61°							60°

Figure 2-8. Natural Trigonometric Functions Table.

LESSON TWO

PRACTICE EXERCISE

The following items will test your grasp of the material covered in this lesson. There is only correct answer to each item. When you have completed the exercise, check your answers with the answer key that follows. If you answer any item incorrectly, study again that part of the lesson which contains the portion involved.

1. How far apart are data blocks produced by the AN/AYA-10 ADAS?

   A. 2 inches.

   B. 4 inches.

   C. 3/4 inch.

   D. AT start and end of film only.

2. How will an increase in altitude of the aircraft affect the width of the plot?

   A. It will decrease.

   B. It will not effect it.

   C. Remain the same.

   D. It will increase.

3. Where on the plot is the security classification marked?

   A. Top and bottom and at the bottom of the title block.

   B. Top left and bottom right.

   C. Top and bottom only.

   D. Top right and bottom left.

4. What affect will an aircraft's turn along the flight path have on the plot?

   A. The plot will narrow.

   B. Remain the same.

   C. No affect.

   D. The plot will bulge.

LESSON TWO

PRACTICE EXERCISE

ANSWER KEY AND FEEDBACK

Item	Correct Answer and Feedback
1.	A. Data blocks are 2 inches apart on IR imagery (page 39, para 3).
2.	D. The width of the IR imagery plot will increase as the aircraft increases its altitude (pages 40/41, para 4a(1) /fig 2-3).
3.	A. Security classification is marked on the top and bottom of the overlay and the bottom of the title block (page 38, para la).
4.	D. The plot will bulge since more ground is covered on one of the flight paths than the other (page 41, para 4b).