

28 March 1969

AD 719679
Materiel Test Procedure 6-2-035*
Electronic Proving Ground

U. S. ARMY TEST AND EVALUATION COMMAND
COMMODITY ENGINEERING TEST PROCEDURE

COMBAT SURVEILLANCE SYSTEMS

1. OBJECTIVE

The objective of the procedures outlined in this MTP is to provide a means of evaluating the technical performance and characteristics of combat surveillance sensor systems and determining their suitability for military use.

2. BACKGROUND

Combat surveillance systems provide the army commander with the capability for a continuous systematic watch (all weather, day and night) over the battle area. Included in the systems are all of the personnel, materiel, and procedures necessary to obtain timely intelligence data for support of tactical ground operations. Intelligence data may be information (recorded or unrecorded) obtained through observations by aircraft crews and ground observers. These may be enhanced by the use of sensory equipment to increase accuracy and detail.

Much intelligence data and information may be obtained in this manner, however, several factors impose limitations on visual aerial surveillance, such as, speed and vibration of the aircraft, the distance from which an observer must observe, enemy air defense and concealment measures, natural ground cover, and poor visibility due to adverse atmospheric conditions.

To overcome some of these limitations and to complement the visual surveillance, permanent record imagery is essential before, during, and after combat operations. This imagery, obtained with airborne and ground based sensors, can be studied, analyzed, and interpreted to provide more detailed, accurate, and complete intelligence information than that derived from visual observation. The tradeoff for the record imagery is the time required for processing which may reduce or negate the value of the data collected concerning transient and fleeting targets.

To maximize the commander's capability for combat surveillance, it is essential that processing time for permanent record imagery be minimized.

The combat surveillance system may be represented by the block diagram of Figure 1.

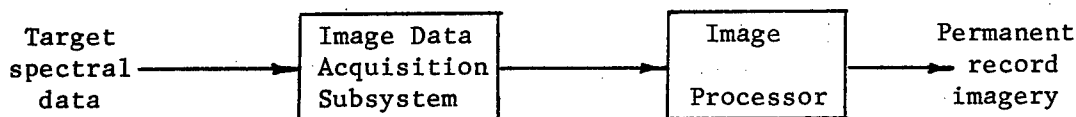


Figure 1. Combat Surveillance System Functions

The importance of the equipment mission indicates the need for engineering tests

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to ensure that this equipment meets applicable requirements and has the specialized characteristics necessary for its intended use.

3. REQUIRED EQUIPMENT

a. Actual, simulated, or hybrid combat surveillance system to include:

- 1) Aircraft and avionic support facility
- 2) Surveillance, environmental and orientation sensors
- 3) Sensor data recorder
- 4) Sensor data processors
- 5) Guidance and control (when appropriate)
- 6) Data transmission (when appropriate)
- 7) Signature acquisition subsystem data correlator

b. Test target appropriate to the sensors, such as:

- 1) Three-bar target
- 2) Edge analysis target
- 3) Infrared targets (passive and active)
- 4) Radar target arrays (coherent and non-coherent)

c. Test targets (line-pair) which simulate actual targets, such as:

- 1) Personnel
- 2) Vehicles
- 3) Supplies
- 4) Artillery
- 5) Mortar

d. Photometer

e. Range finder

f. Transit

g. Theodolites

h. Camera equipment

i. Microdensitometer

j. Sensitometer

k. Meteorological support facility

l. CORN mobile target facility (see Appendix A)

4. REFERENCES

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- R. U. S. Army Test and Evaluation Command Regulation 385-14.
- S. MTP 3-1-002, Confidence Intervals and Sample Size
- T. MTP 5-2-520, Ranging Systems Test
- U. MTP 6-2-020, Radar Antenna Subsystem Tests
- V. MTP 6-2-507, Safety

5.

SCOPE

5.1 SUMMARY

5.1.1 Technical Characteristics

The procedures presented in this MTP provide general guidance for evaluating the technical performance and characteristics of combat surveillance systems. This will be accomplished by obtaining permanent record imagery of reference targets with sensors under controlled conditions, and by measurement of the final image density characteristics to provide system modulation transfer function and resolution. The specific tests to be performed along with their intended objectives are listed below:

a. Maximum and Minimum Acquisition (detection ranges for specific targets) - The objective of this subtest is to determine the operating range of the acquisition sensor under various conditions.

b. Maximum and Minimum Recognition (resolution ranges) - The objective of this subtest is to determine the capability of the surveillance equipment to distinguish between different kinds of targets at minimum and maximum ranges.

c. Scan Rates - The objectives of this subtest are to determine:

- 1) If the equipment can scan the sector for which it is designed.
- 2) The scanning rate.

d. Target Saturation Level - The objective of this subtest is to determine the specified number of targets the equipment can scan or detect, without interference.

e. Lock on Time After Detection; Accuracy of Location of Target in Space (Radar) - The objectives of this subtest are to determine:

- 1) Time between "target designate" and "target acquire" (the instant of lock-on).
- 2) Accuracy of the tracking radar.

f. Maximum and Minimum Elevation Angles - The objectives of this subtest are to determine:

- 1) Maximum angle efficiency of the system compared with results obtained by optical devices.
- 2) Minimum and maximum angle of acquisition capability of the test item.

g. Line of Resolution - The objective of this subtest is to determine the ability of the test item to obtain appropriate resolutions at threshold ranges using the image transform methods.

h. Flight Test of Image Data Acquisition Subsystem - The objective of this subtest is to obtain permanent record imagery of selected targets with the particular airborne sensor for each velocity/altitude combination required for image sensor operation.

i. Laboratory Test of Image Processor Subsystem - The objective of this subtest is to obtain a measure of the final image density characteristics required to provide modulation transfer function or resolution.

5.1.2 Common Engineering Tests

Not included in this MTP are the following Common Engineering Tests which apply to these commodities:

- a. 6-2-500, Physical Characteristics
- b. 6-2-502, Human Factors Engineering
- c. 6-2-503, Reliability
- d. 6-2-504, Design for Maintainability

5.2 LIMITATIONS

This document is limited to those systems which produce permanent record imagery; it excludes the testing of systems for detecting nuclear radiations and electronic intelligence (ELINT). Tests of the support vehicles and data links are not included, although these form a part of the system.

6. PROCEDURES

6.1 PREPARATION FOR TEST

a. Select test equipment ideally having an accuracy of at least ten times greater than that of the function to be measured, that is in keeping with the state-of-the-art, and with calibrations traceable to the National Bureau of Standards.

b. Record the following information:

- 1) Nomenclature, serial number(s), manufacturer's name and function of the item(s) under test.
- 2) Nomenclature, serial number, accuracy tolerances, calibration requirements, and last date calibrated of the test equipment selected for the tests.

c. Ensure that test personnel include image evaluators who are trained in the techniques of sensitometry and microdensitometry, and that all personnel are familiar with the required technical and operational characteristics of the item under test, such as stipulated in Qualitative Material Requirements (QMR), Small Development Requirements (SDR), and Technical Characteristics (TC).

d. Review all instructional material issued with the test item by the manufacturer, contractor, or government, as well as reports of previous tests conducted on the same types of equipment, and familiarize all test personnel with the contents of such documents. These documents shall be kept readily available for reference.

e. Thoroughly brief all test personnel on the purpose of the test, the results expected, and the spectral and dimensional characteristics of the

appropriate sensors of the system.

f. Prepare record forms, as required, for systematic entry of data, chronology of test, and analysis in final evaluation of the test item.

g. Prepare adequate safety precautions to provide safety for personnel and equipment, and ensure that all safety SOP's are observed throughout the test and that the test item has successfully completed MTP 6-2-507, Safety.

- NOTES: 1. The precautions, hazard evaluations, power density, exposure levels, medical surveillance and other controls and safeguard procedures outlined in TB MED 270 shall be complied with.
2. The services of the Army Environmental Hygiene Agency (AEHA), Edgewood Arsenal, Md., are available for assistance in evaluating and measuring power densities from these devices for human hazards evaluation. It is suggested that prior to each test of a new type item, that assistance from AEHA be requested through channels, if considered necessary, as per TECOMR 385-14.

h. Thoroughly inspect the test item for obvious physical and electrical defects such as cracked or broken parts, loose connections, bare or broken wires, loose assemblies, bent fragile parts, or corroded plugs or jacks. All defects shall be noted and corrected before proceeding with the test.

i. Prior to beginning any subtest, verify correct power source, necessary test instrumentation and inter-connection cabling, and that the equipment is aligned, if necessary, as specified in the pertinent operating instructions to ensure, insofar as possible, it represents an average equipment in normal operating conditions.

j. Prepare a test item sample plan to ensure that a sufficient number of images and sample measurements are obtained to assure statistical confidence of final data in accordance with MTP 3-1-002. Provisions shall be made for modification during test progress as may be indicated by monitored test results.

NOTE: Recorded imagery will be used for evaluation. Some systems may provide a real time image also.

k. Ensure that a sufficient quantity of film is available to provide for a sufficient number of "samples". The type of film for recording aerial sensor imagery data shall be determined as appropriate to the spectral characteristics of reference targets and of the specific system sensors.

l. Ensure that all aircraft are properly instrumented as required, that arrangements have been made to obtain appropriate meteorological data from the meteorological support facility, and that adequate security measures have been instituted to safeguard classified material and data.

m. Ensure that the location and time frame for the tests has been selected to optimize the effects of atmospheric and climatic conditions, i.e., minimizing or eliminating undesirable variables, unless it is specifically desired to test the system under particular climatic conditions in a

particular geographic location.

n. Prior to and during performance of field tests, measure and record the following:

- 1) Target characteristics
 - a) Configuration
 - b) Dimensions
 - c) Temperature
 - d) Contrast
 - e) Reflectance
 - f) Emissivity
 - g) Target background characteristics
- 2) Meteorological data
 - a) Temperature
 - b) Humidity, relative or absolute
 - c) Temperature gradient
 - d) Atmospheric pressure
 - e) Precipitation
 - f) Wind speed and direction
 - g) Pibal data
 - h) Frequency of readings
 - i) Source of data

6.2 TEST CONDUCT

NOTE: Modification of these procedures shall be made as required by technical design of the item under test and availability of test equipment, but only to the extent that such modifications will not affect the validity of the test results.

6.2.1 Maximum and Minimum Acquisition (Detection) Speed and Range

a. Determine the maximum and minimum detection ranges and speed of the test item, in accordance with MTP 5-2-520, by moving (flying when appropriate) suitable targets at very slow to fast speeds toward the sensor under test.

b. Observe and record the range (and angles when appropriate) and speed at the time the target is first detected, and again when the target is too close to the sensor to be detected.

6.2.2 Maximum and Minimum Recognition (Resolution) Ranges

a. Move at least two targets of a specific type (representing trucks or other objects) toward the sensor under test.

b. Observe and record the range where detection first occurs and range where identification (separation) occurs.

c. Repeat Steps (a) and (b) above, with other target types.
(See MTP 5-2-520 for further clarification on radar tests).

6.2.3 Scan Rates

a. Determine: (1) the ability of the test item to rotate, scan, or move through its prescribed range by locating selected targets at various ranges and azimuths from the test item: (2) the ability of the item to detect targets within its designated scanning sector; and (3) if continuous scanning or the jump and pause method is more suitable. Note the time required for each scan or movement. (See procedure given in MTP 6-2-020 for radars).

b. Record the following information:

- 1) Time interval required for test item to rotate through its prescribed positioning.
- 2) Measurement (in miles or degrees) of the prescribed scanning sector.
- 3) Time interval required to scan the scanning sector.

6.2.4 Target Saturation Level (Radar)

a. Insert a signal generator between the antenna and receiver of the item under test and progressively increase the number of pulses visible on the display device.

b. Observe the point at which the number of blips are too numerous to be identifiable.

c. Record the following:

- 1) Description of the test equipment used
- 2) Number of pulses introduced to produce saturation on the display device.

6.2.5 Lock-on Time After Detection (Transfer to Track Time); Accuracy of Location in Space (Transfer to Track Accuracy) (Radar)

6.2.5.1 Transfer to Track Time

a. Acquire a target with the acquisition radar.

b. Start a strip recorder, stopwatch, or event recorder at the instant of first detection of the target by the acquisition radar.

c. Designate the target to the tracking radar and stop the event recorder, strip recorder, or stopwatch at the event "Target-designate" (the instant of relaying the target coordinates to the tracking radar).

d. Measure and record the elapsed time between first detection of the target and "target-designate".

e. Repeat steps (a) through (d) above, a minimum of three times.

f. Acquire a target with the acquisition radar and designate the target to the tracking radar.

g. Start a strip recorder, event recorder, or stopwatch at the even "target-designate" and stop the recorders or stopwatch at the event

"target-acquire" (the instant of "lock-on" in automatic tracking by the tracking radar).

h. Measure and record the elapsed time between "target designate" and "target-acquire".

i. Repeat steps (f), (g), and (h) above, a minimum of three times.

6.2.5.2 Transfer to Track Accuracy

a. Acquire a slow moving target, on a radial course, with the acquisition radar and designate the target to the tracking radar.

b. Note and record the tracking radar azimuth dial reading when the tracking radar acquires to the designated coordinates of the acquisition radar.

c. Note and record the track radar azimuth dial reading when the tracking radar begins automatic tracking.

d. Acquire a slow moving target, on a circular course, with the acquisition radar and designate the target to the tracking radar.

e. Note and record the track radar range dial reading when the tracking radar acquires to the designated acquisition radar coordinates.

f. Note and record the track radar range dial reading when the tracking radar begins automatic tracking.

g. Acquire a target at long slant range with the acquisition radar and designate the target to the tracking radar.

h. Note and record the track radar elevation dial reading when the tracking radar acquires to the designated acquisition radar coordinates.

i. Note and record the track radar elevation dial reading when the tracking radar begins automatic tracking.

j. Repeat steps (a) through (i) above, a minimum of three times.

6.2.6 Maximum and Minimum Elevation Angles

6.2.6.1 Maximum Angle Efficiency

a. Mount motion picture cameras with coded timing film in a suitable position on the item under test to photograph the azimuth and elevation dials.

b. Acquire and automatically track an aerial target flying a crossing course close to the test item. Start the time coded motion picture cameras.

c. If the maximum angular velocity of the target exceeds the maximum angular tracking rate of the item under test, the target will be lost. If this occurs, note and record at what slant range the target is lost.

d. Acquire and automatically track an aerial target flying a radial course directly over the item under test. Start the time coded motion picture cameras.

e. If the maximum angular velocity of the target exceeds the maximum angular tracking rate of the test item, the target will be lost. If this occurs, note and record at what slant range the target is lost.

6.2.6.2 Minimum and Maximum Angle of Acquisition

- a. Using suitable targets, at a prescribed range, determine the minimum and maximum angle of acquisition.
- b. Determine elevation tracking rate, e.g., 30°/sec.
- c. Employ time coded motion picture cameras for recording.
- d. Record the following for each target acquired:
 - 1) Description of target
 - 2) Minimum and maximum angles of acquisition
 - 3) Elevation tracking rate

6.2.7 Line Resolution (See Appendix B)

- a. Determine and record the capability of the test item to resolve one line pair in the minimum exterior projected dimension of a selected target (detection), three line pairs (recognition), and six line pairs (identification).

6.2.8 Flight Test of Image Data Acquisition Subsystem

- a. Prescribe aircraft flight paths, as required, for airborne sensor equipment on map overlays or scaled diagrams showing the following minimum information:

- 1) Length and direction of data runs
- 2) Altitudes
- 3) Data points
- 4) Ground target displays and reference points.

NOTE: To ensure stabilization of aircraft and sensor performance, the flight profile shall provide for a relatively long flight line approach over the test target area. Economy may be gained in terms of flight costs by the use, where possible, of multiple target displays along one flight line, thereby decreasing the number of necessary aircraft passes over the area.

- b. Energize all equipment and record sensor data as latent imagery on film emulsion while flying over the test target area at the velocity/altitude (V/H) combination required for image sensor operations.

- c. Record the following information:

- 1) Velocity (V)
- 2) Altitude of aircraft (H)
- 3) Heading of aircraft
- 4) Flight line direction
- 5) Tilt angle of sensor (T)
- 6) Swing angle of sensor(s)
- 7) Pitch, roll, and yaw of sensor
- 8) Pitch rate, roll rate, and yaw rate of sensor
- 9) Focal length (photographic)

- 10) Shutter speed (photographic-fixed frame)
- 11) Camera sweep velocity (photographic-panoramic)
- 12) Image width (IW) (Infrared and SLAR)
- 13) Scan angle (θ) (Infrared)
- 14) Film velocity (Infrared)
- 15) Range (R) (SLAR)
- 16) Space positioning data (as appropriate)

d. Repeat Steps (b) and (c) above, as required for each velocity/altitude combination required for image sensor operation.

6.2.9 Laboratory Test of Image Processor Subsystem

6.2.9.1 Processor Chemistry

a. Using a sensitometer, expose sensitometric strip onto a piece of control film (standard), and record the exposures, E , of each step.

NOTE: Exposures are products of the intensity, I , of the illumination on the film and time, t , of the exposure expressed in meter-candle-seconds, that is, $E = It$.

b. Pass the exposed control film through the processor at standard processing conditions (temperature, time, agitation).

c. Measure the densities, D , of the steps in the film with a densitometer and record the values.

d. Obtain the logarithms (base 10) of the exposures, E , and plot the characteristics curve ($D \log E$), exemplified in Figure 2.

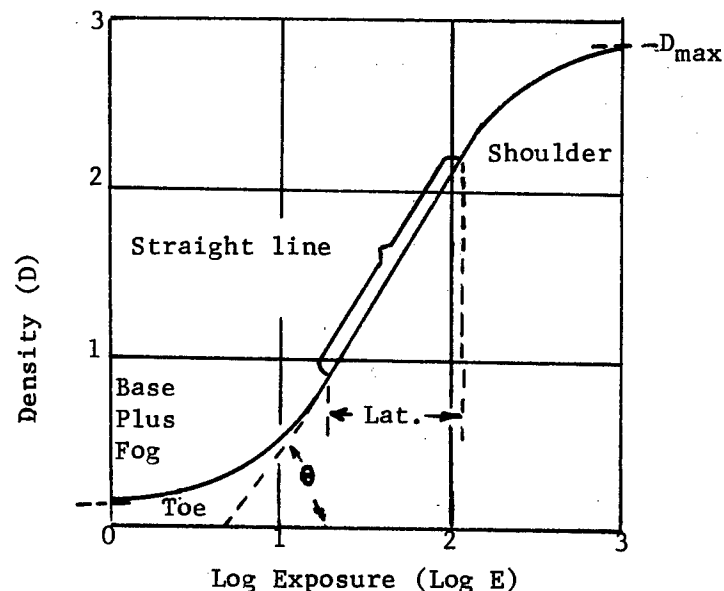


Figure 2. Typical Characteristic Curve

e. From the plotted characteristics curve, determine gamma ($\gamma = \tan \theta$) and speed of the film. If gamma and speed do not coincide with the established control values, replenish chemistry and repeat test.

6.2.9.2 Test Film and Processor

a. Print sensitometric strip onto five separate pieces on film of the same rock or of the same emulsion number as the image film and record the exposure, E. Spectral characteristics of sensitometer light should be similar to those exposing the image film.

b. Pass each of the five strips through the processor for five different time periods, t_1 , through t_5 . Note that if necessary the temperature of the processor chemistry could also varied.

c. Read the transmittance of each step of the sensitometric strips in density units, D, on a densitometer and record the values.

d. Plot the measured density of each of the steps (about 20) versus the logarithm of the known exposure of each of the steps to give the D Log E characteristics curve for each processing time, t, as exemplified in Figure 3.

e. Determine gamma and film speed from each curve and record data. If the desired gamma range is not indicated by the determined gamma values, explore other processing time periods and chemistry temperatures within the acceptable limits for the particular processor to determine the total possible range of gammas.

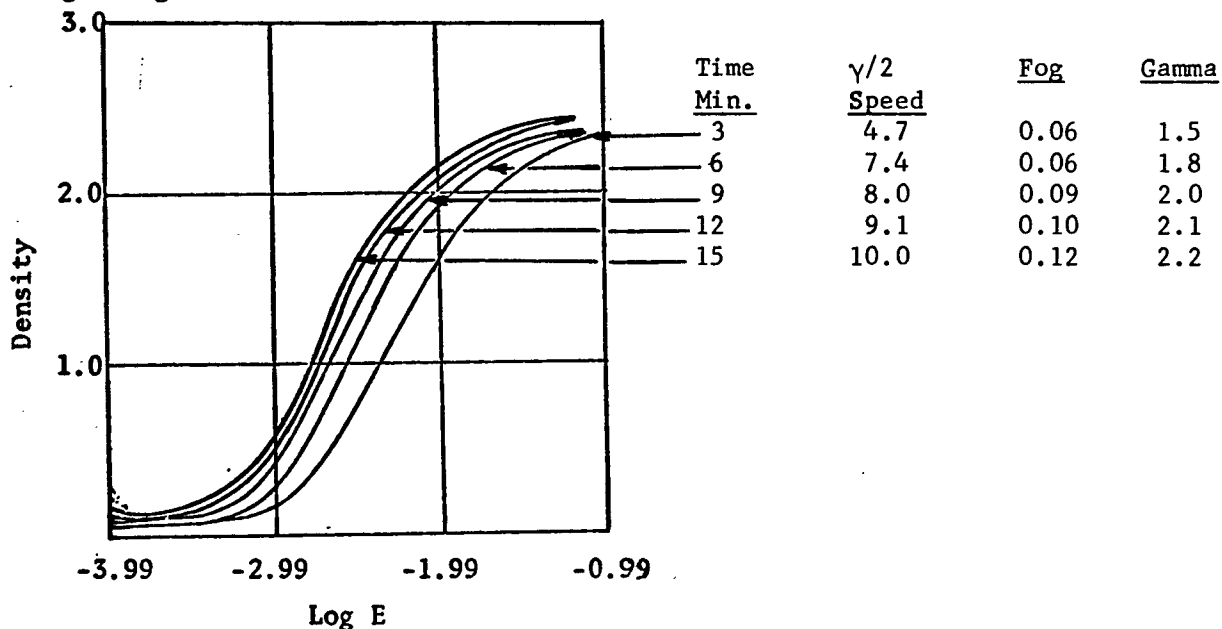


Figure 3. Characteristic Curve for Different Processing Periods.

6.2.9.3 Permanent Record Imagery

- a. Prior to processing the image film, expose a sensitometric strip onto both the leading and trailing ends, if possible.
- b. Pass the image film through the processor for the appropriate time period and temperature as indicated by the results of paragraph 6.2.9.2, above.

6.3 TEST DATA

6.3.1 Preparation for Test

- a. Data to be recorded prior to testing shall include:
 - 1) Nomenclature, serial number(s), manufacturer's name and function of the item(s) under test.
 - 2) Nomenclature, serial number, accuracy tolerances, calibration requirements, and last date calibrated of the test equipment selected for the tests.
 - 3) Discrepancies and deficiencies noted in equipment inspection prior to start of the test.
- b. The following data shall be recorded prior to and during performance of field tests:
 - 1) Target characteristics
 - (a) Configuration
 - (b) Dimensions
 - (c) Temperature
 - (d) Contrast
 - (e) Reflectance
 - (f) Emissivity
 - (g) Target background characteristics
 - 2) Meteorological data
 - (a) Temperature
 - (b) Humidity, relative or absolute
 - (c) Temperature gradient
 - (d) Atmospheric pressure
 - (e) Precipitation
 - (f) Wind speed and direction
 - (g) Pibal data
 - (h) Frequency of readings
 - (i) Source of data

6.3.2 Test Conduct

Data to be recorded in addition to specific instructions listed

below for each subtest shall include:

- a. A block diagram of the test setup employed in each specified test. The block diagram shall identify by model and serial number, all test equipment and interconnections (cable lengths, connectors, attenuators, etc.) and indicate control and dial settings where necessary.
- b. Photographs or motion pictures (black and white or color), sketches, charts, graphs, or other pictorial or graphic presentation which will support test results or conclusions.
- c. An engineering logbook containing, in chronological order, pertinent remarks and observations which would aid in a subsequent analysis of the test data. This information may consist of a description of the equipment or components, and functions and deficiencies, as well as theoretical estimations, mathematical calculations, test conditions, intermittent or catastrophic failures, test parameters, etc., that were obtained during the test.
- d. Test item sample size (number of measurement repetitions)
- e. Instrumentation or measurement system mean error stated accuracy.

6.3.2.1 Maximum and Minimum Acquisition (Detection) Speed and Ranges

The following shall be recorded:

- a. The range (and angles where appropriate) at the time the target is first detected.
- b. The minimum speed for detection (when appropriate)
- c. The range (and angles where appropriate) when the target is too close to the sensor to be detected.

6.3.2.2 Maximum and Minimum Recognition (Resolution) Ranges

The following shall be recorded:

- a. Description of targets used
- b. The range where detection first covered
- c. The range where identification (separation) occurred

6.3.2.3 Scan Rates

The following shall be recorded:

- a. The time interval required for test item to rotate through its prescribed positioning.
- b. The measurement (in miles or degrees) of the prescribed scanning sector.
- c. The time interval required to scan the scanning sector.

6.3.2.4 Target Saturation Level (Radar)

The following shall be recorded:

- a. Description of the test equipment used.
- b. The number of pulses introduced to produce saturation on the display device.

6.3.2.5 Lock-on Time After Detection (Transfer to Track Time); Accuracy of Location in Space (Transfer to Track Accuracy) (Radar)

6.3.2.5.1 Transfer to Track Time

The following shall be recorded:

- a. Times from first detection to "target designate".
- b. Times from "target designate" to "target acquire".

6.3.2.5.2 Transfer to Track Accuracy

The following shall be recorded:

- a. Azimuth dial reading when track radar acquires to designated acquisition radar coordinates.
- b. Dial reading when track radar begins automatic tracking.
- c. Range dial reading when track radar acquires to designated acquisition radar coordinates.
- d. Range dial reading when track radar begins automatic tracking.
- e. Elevation dial reading when track radar acquired to designated acquisition radar coordinates.
- f. Elevation dial reading when track radar begins automatic tracking.

6.3.2.6 Maximum and Minimum Elevation Angles

6.3.2.6.1 Maximum Angle Efficiency

The following shall be recorded:

- a. Slant range at which target is lost in azimuth.
- b. Slant range at which target is lost in elevation.
- c. The number of yards the range moves in 20 seconds.

6.3.2.6.2 Minimum and Maximum Angle of Acquisition

The following shall be recorded:

- a. Capability of the test item to resolve one line pair in the minimum exterior projected dimension of each target,
- b. Capability of the test item to resolve three line pairs of each target.
- c. Capability of the test item to resolve six line pairs of each target.

6.3.2.8 Flight Test of Image Data Acquisition Subsystem

The following shall be recorded for each velocity/altitude combination required for the image acquisition process:

- a. Velocity (V)
- b. Altitude of aircraft (H)
- c. Heading of aircraft
- d. Flight line direction
- e. Tilt angle of sensor (T)
- f. Swing angle of sensor (S)
- g. Pitch, roll, and yaw of sensor
- h. Pitch rate, roll rate, and yaw rate of sensor
- i. Focal length (photographic)
- j. Shutter speed (photographic-fixed frame)
- k. Camera sweep velocity (photographic-panoramic)
- l. Image width (I_w) (Infrared and SLAR)
- m. Scan angle (θ) (Infrared)
- n. Film velocity (Infrared)
- o. Range (R) (SLAR)
- p. Space positioning data (as appropriate)

6.3.2.9 Laboratory Test of Image Processor Subsystem

6.3.2.9.1 Processor Chemistry

Processor chemistry data to be recorded shall be the D log E curve, gamma, and film speed obtained to test the adequacy of the chemistry.

6.3.2.9.2 Test Film and Processor

Test film and processor data to be recorded shall be the D log E curve, gamma, and film speed for each combination of processing period and temperature.

6.3.2.9.3 Permanent Record Imagery

Image data (transparency or opaque) shall be recorded in the form of final permanent record imagery.

6.4 DATA REDUCTION AND PRESENTATION

6.4.1 General

The output data in the form of permanent record imagery shall be analyzed with a microdensitometer and microscope to yield a descriptive measure of system performance in terms of the system modulation transfer function (MTF) and system resolution

6.4.2 Modulation Transfer Function

a. Modulation transfer function shall be derived from the edge gradient in the final permanent record imagery of the edge analysis targets.

b. Using a microdensitometer, trace across the image edge at each of at least three different points thereby obtaining at least three density (D) versus distance (d) curves. A typical microdensitometer edge trace is shown in Figure 4a.

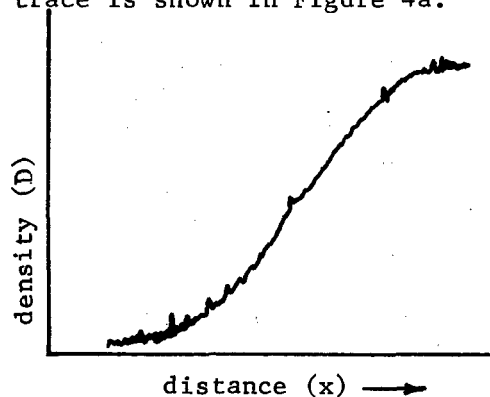


Figure 4a

Microdensitometer Trace of
Edge Density

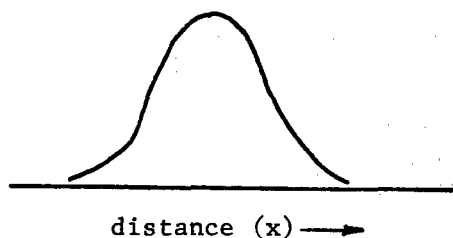


Figure 4c

Line Spread Function
(Derivative of Edge Trace)

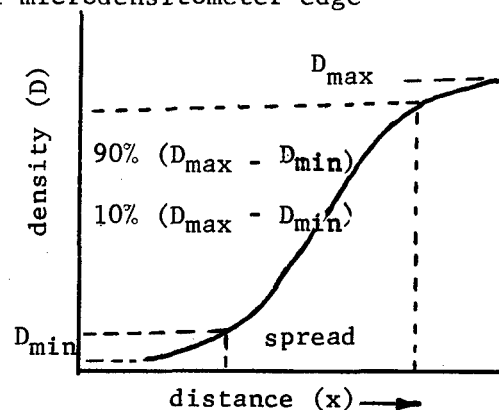


Figure 4b

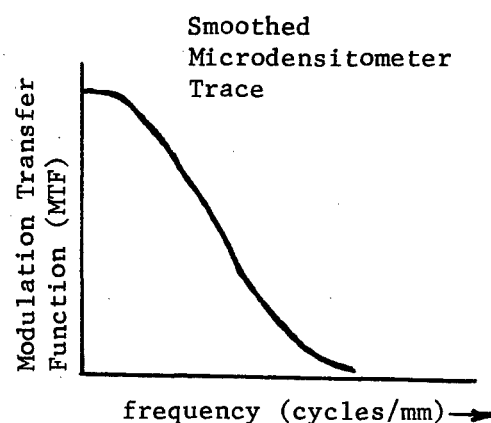


Figure 4d

Fourier Transform
of Spread Function,
or Modulation
Transfer Function

Figure 4. Edge Analysis Sequence

c. Superimpose the three traces and accomplish manual smoothing by drawing a smooth curve approximating the average characteristics to yield a final edge density curve as shown in Figure 4b.

d. Convert the density, D , scale units (y-axis) to effective exposure (intensity) units by referring to the $D \log E$ curve plotted for the test film. Plot the edge intensity curve, or edge spread function. Note that for maximum precision the exposure of the target image should be adjusted so that density extremes will be on the straight line portion of the $D \log E$ curve. If any portion of the edge image distribution lies below the toe or above the shoulder of the $D \log E$ curve, then analysis cannot be made.

e. Obtain the line spread function by taking the derivative of the edge spread function using appropriate mathematical technique or computer program. A typical line spread function is shown in Figure 4c.

f. Compute the Fourier transform of the line spread function using appropriate mathematical technique or computer program to yield the modulation transfer function, exemplified in Figure 4d.

6.4.3 Resolution

Resolution shall be determined for each recorded V/H ratio by examining the permanent record imagery of three-bar patterns or point sources through a microscope under adequate magnification to determine the finest pattern in which the bars, or the closest spacing in which the point sources can be distinguished separately. The numerical value of ground resolution in lines per foot, or in feet for point targets, shall be recorded.

NOTE: An approach to evaluation of systems performance would be to compare the reduced data, that is MTF and resolution, to those predicted by a prior systems analysis or by a mathematical model. These techniques can provide a capability for predicting the distribution of output imagery obtainable from a given target-background-environment-equipment combination.

Although image prediction in the sense of absolute accuracy cannot be carried out, there is reasonable logic in its use for comparative systems studies.

APPENDIX A

TARGETS

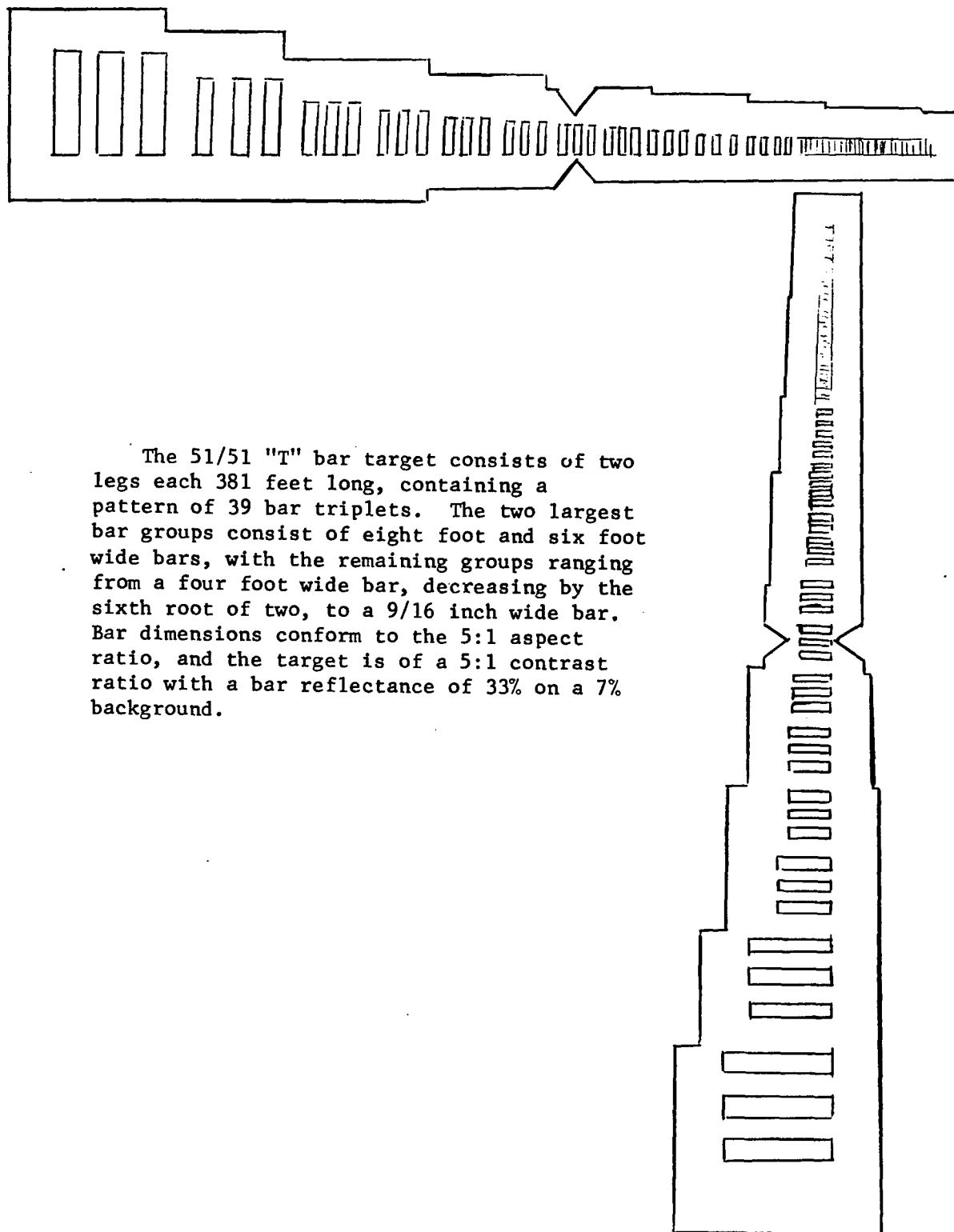
Targets used for determination of modulation transfer function (MTF) generally include edges, lines, and sinusoids while for determination of resolution, it is the three-bar pattern with three different contrast ratios.

The choice of target, is a matter of arbitrary selection based on availability, details of the test, data analysis equipment, and personnel preference. It must be said that different results are to be expected when different targets are used. This is the inevitable result of attempting to use linear analysis with a basically non-linear system component, the photographic emulsion.

It might appear that sinusoidal target inputs for determination of MTF would be best because of their basic nature, that is, since they are the fundamental units of Fourier analysis. However, at present, there is no conclusive proof that the transfer function thus derived is more accurate or practically useful than those obtained with edge or line target inputs.

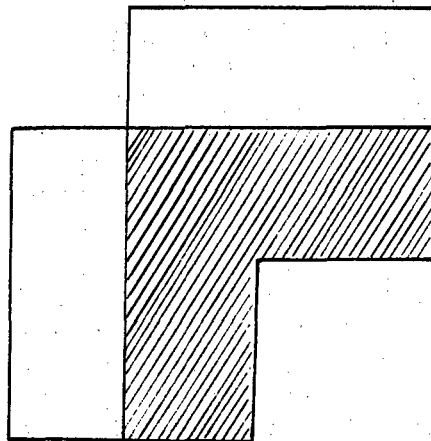
Typical aerial targets provided by the Controlled Range Network* are identified in Figures A-1 through A-6.

* The Controlled Range Network (CORN) is maintained and operated for the U. S. Air Force under Contract AF 33 (657) - 15798, and is under the direction of the Photographic Branch, Directorate of Reconnaissance Engineering, Wright-Patterson AFB, Ohio. The CORN program consisting of 12 mobile units based at eight strategic locations across the continental U. S. The use of the CORN facilities is available to all services and agencies of the Federal Government.



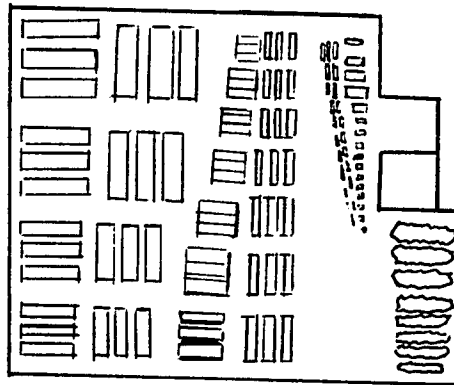
The 51/51 "T" bar target consists of two legs each 381 feet long, containing a pattern of 39 bar triplets. The two largest bar groups consist of eight foot and six foot wide bars, with the remaining groups ranging from a four foot wide bar, decreasing by the sixth root of two, to a 9/16 inch wide bar. Bar dimensions conform to the 5:1 aspect ratio, and the target is of a 5:1 contrast ratio with a bar reflectance of 33% on a 7% background.

Figure A-1. 51/51 "T" Bar Target



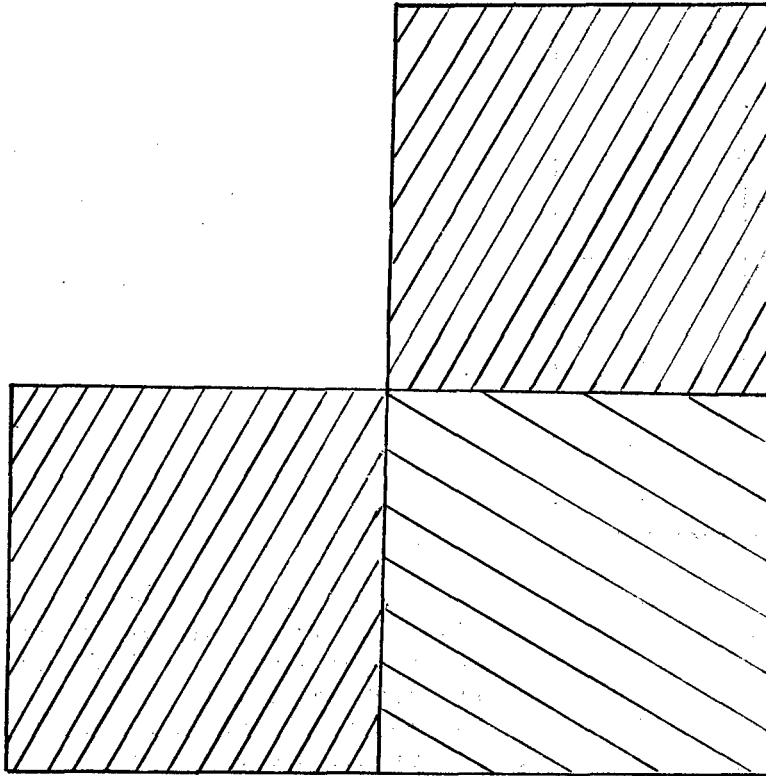
The 100 foot edge analysis target is designed for the microdensitometric evaluation of edge gradients. The target consists of two perpendicular 100 foot edges having reflectance of 4% and 37%.

Figure A-2. Edge Analysis Target



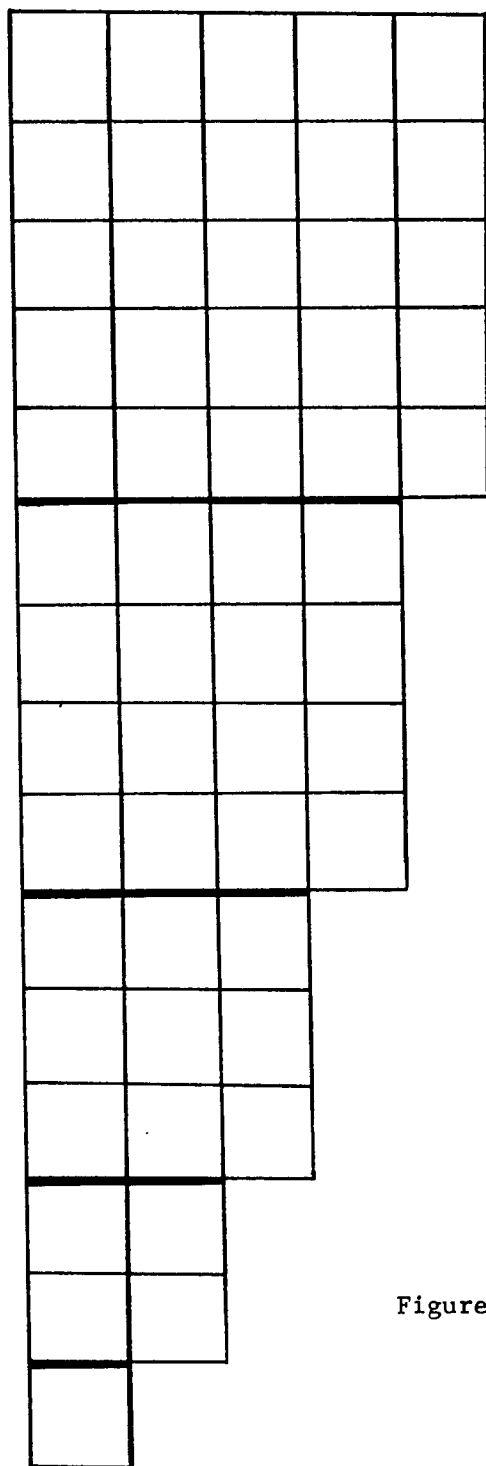
The Mil. Std. target consists of high contrast three bar groupings, horizontally and vertically displayed. Bar sizes range from a four foot wide bar, decreasing by the sixth root of two, to a 9/16 inch wide bar. The target also contains three sine wave groupings of 1, 1.5, and 2 foot wide sine wave targets.

Figure A-3. Mil. Std. 150A Target



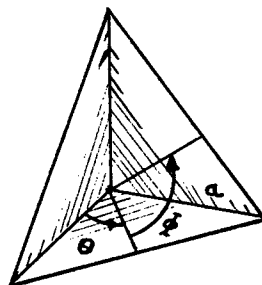
The passive infrared target array consists of a 100 foot edge resolution target, comprised of a high emissivity and a low emissivity material. The target is used to evaluate system spread function. The target array also consists of a six step passive thermal scale, comprised of six varying emissivity materials, used to evaluate the thermal sensitivity of an infrared system. The infrared materials are relatively spectrally flat from 2.5 to 22 microns. The target is monitored with an infrared radiometer during use to establish emitted energy levels.

Figure A-4. Passive Infrared Target Array.



The active infrared target array consists of three lines of electrically heated target elements. Each line consists of one each target, 1 x 1, 2 x 2, 3 x 3, 4 x 4, and 5 x 5 feet square. The targets can be heated above background to any desired temperature up to 40°C. Each target element is individually temperature controlled by a control console. Temperatures can be maintained to $\pm 5^\circ \text{C}$. The target array is powered by portable electric generators. Target and background surface temperatures are monitored by use of thermistor probes. The target is used to evaluate the thermal sensitivity of short wavelength systems.

Figure A-5. Active Infrared Target Array.



The non coherent radar resolution array utilizes a series of 35 twelve inch edge diameter corner reflectors configured in a "L" shaped array to measure ground resolution between 50 and 4 feet. In addition, one dynamic range target is configured of a series of 11 corner reflectors with a 3 db increase in cross sectional area between each reflector in the progression.

Figure A-6. Non Coherent Radar Resolution Array.

COHERENT RADAR (MTI) RESOLUTION

The coherent radar resolution array consists of approximately 1100 eight inch diameter aluminum hemispheres arranged in a pseudo random distribuiton within a 150 foot square area. The target is used as an edge target to evaluate the spread function of a coherent radar system. It is theoretically useful to systems having approximately 50 foot ground resolution or less. The target provides a contrast in excess of 6 db above background. This is an experimental research target, and the individual hemispheres can be configured into various patterns, such as a line target, or V shaped target.

APPENDIX B

TARGET-SENSOR IMAGE SIGNATURE ANALYSIS

SENSORS

The function of sensors in image signature acquisition systems is to extend the range and field-of-view (and to restore under adverse-weather, day and night conditions) the faculty of human sight.

A marked difference exists between the capabilities of various sensors. Each sensor operates within a particular portion of the electromagnetic spectrum and reacts differently to targets, terrain, and natural phenomena. The use of optical devices and photography is hampered during periods of reduced visibility such as occasioned by rain, heavy clouds, and darkness. Infrared energy is rapidly reduced by heat-absorbing characteristics of rain, snow, or hail. Radar can operate through clouds and rain only with certain limitations.

The capability of sensors is an important consideration in their selection. Each sensor can provide an image signature which is complementary; for example, from the sensing of movement of an object a radar signature may provide detection information, while from the sensing of thermal emission or reflection, an infrared signature may provide recognition information.

SIGNATURE ANALYSIS

Signature analysis is usually thought of in terms of instrument output data generated because of some particular emission or trait of a target which may be different from its background or environment.

Image signature data are usually acquired where a visual representation of the target is most useful, and where interpretation is used as a descriptive characteristics measure of the signature, such as, detection, recognition, and identification.

Image signatures can be readily interpreted from what is seen and understood, and do not require the elaborate instrumentation and data interpretation necessary in radiometric and photometric methods.

SYSTEM PERFORMANCE

The ground combat surveillance system must be capable of providing the following:

- a. A continual watch over the battle area, or zone of responsibility during a given time period.
- b. Intelligence information on the nature, and when required, the location, of the target on a real-time or near real-time basis.

The nature of the target is described by the system through the

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functions of detection, recognition, and identification, as interpreted from correlated sensor image signatures.

Criteria for system performance of the three functions can be determined empirically and constitute the image transform method, shown in Figure B-1, using line pair targets to determine appropriate resolutions at threshold ranges.

For example, assume that one critical dimension is the visible minimum exterior projected dimension. If the system can resolve one line pair in that dimension, then it will be able to detect the target. If the system can resolve three line pairs in that dimension, then it can recognize the target, and if it can resolve six, it will be able to identify the target.

Using this approach, targets must be devised for each general class of anticipated target sizes, which are appropriate to the system image sensors.

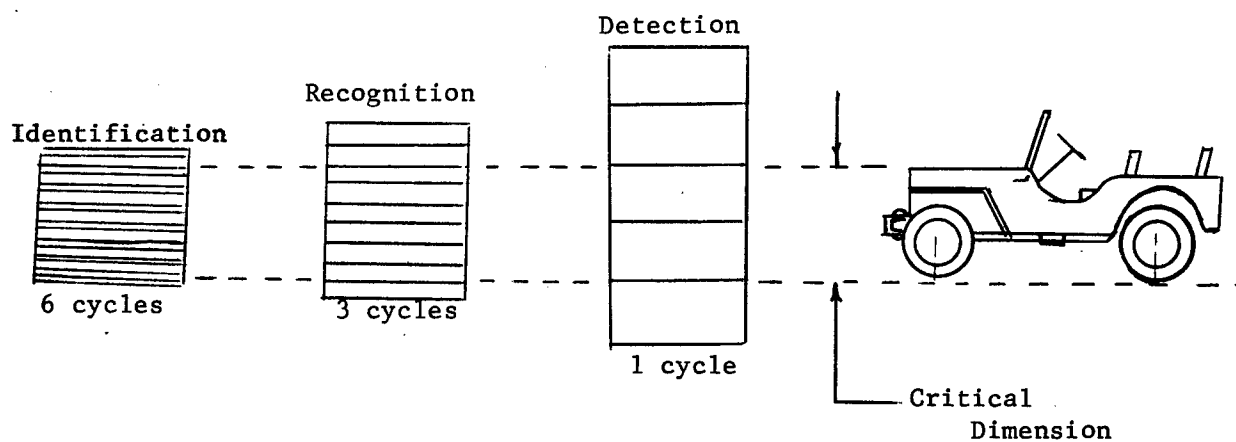


Figure B-1. Image Transforms.