UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

(4) LEVEL II

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER: TOP-6-2-135 (18) TECOM (19)	2. GOVT ACCESSION NO.: AD-A106 711
3. RECIPIENT'S CATALOG NUMBER	
4. TITLE (and Subtitle): US ARMY TEST AND EVALUATION COMMAND TEST OPERATIONS PROCEDURE (6) INFRARED EQUIPMENT, GENERAL.	5. TYPE OF REPORT & PERIOD COVERED: (9) Final report
	6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s)	8. CONTRACT OR GRANT NUMBER(s): (15) DAADØ5-80-C-0128
9. PERFORMING ORGANIZATION NAME AND ADDRESS: T&E INTERNATIONAL, INC. 307 S. TOLLGATE ROAD BEL AIR, MARYLAND 21014	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS: DARCOM-R 310-6
11. CONTROLLING OFFICE NAME AND ADDRESS: US ARMY TEST AND EVALUATION COMMAND (DRSTE-AD-M) ABERDEEN PROVING GROUND, MARYLAND 21005	12. REPORT DATE: (11) 13 Oct [redacted]81 (12) 24
	13. NUMBER OF PAGES: 22
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)	15. SECURITY CLASS. (of this report): Unclassified
	15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

DTIC ELECTE NOV 4 1981 S D B

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Infrared Equipment	Detector Angular Subtense	Line Spread Function
Infrared Sensors	Minimum Resolution Temperature	Point Spread Function
Infrared Surveillance	Minimum Differential Temperature	Blackbody
Night Vision Laboratory	Signal Transfer Function	Infrared Spectrum
Field of View	Optical Transfer Function	

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Outlines test procedures and methods for use in evaluating the performance of infrared equipment. Includes checklist and data collection sheets.

(8) 412 617

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

US ARMY TEST AND EVALUATION COMMAND
TEST OPERATIONS PROCEDURE

DRSTE-RP-702-105
*Test Operations Procedure 6-2-135 — 13 October 1981
AD No.

INFRARED EQUIPMENT, GENERAL

1. SCOPE

These procedures outline the particular tests and test methods for use in evaluating the performance and characteristics of general types of infrared surveillance equipment. They serve as a guide in determining the overall efficiency of such equipments as a function of their design and their recorded performance. Notwithstanding the accuracies, frequencies, and levels stated in this test operations procedure (TOP), the specific equipment requirements stated in the appropriate requirements document must be used.

1.1 Subtests. Subtests are broken into two classes: those in which a human observer is directly integrated into the test (subjective) and those in which radiometric or direct electrical measuring equipment is applied (objective).

1.1.1 Subjective Tests:

a. Minimum Resolvable Temperature (MRT). This is defined as the minimum temperature difference needed to resolve a standard four-bar pattern with a 7:1 aspect ratio oriented vertical to the scan. The MRT is the most critical of the subjective parameters.

*This TOP supersedes MTP 6-2-135, 8 December 1967.

Approved for public release; distribution unlimited.

b. Minimum Detectable Temperature (MTD). This is defined as the minimum temperature difference between a square (or circular) target and the background necessary for an observer to perceive the target. The MDT is a function of target size and represents the threshold detection capability of the system under test.

1.1.2 Objective Tests:

a. Signal Transfer Function (SiTF): This is defined as the curve or family of curves which describe the low frequency output luminance (or video voltage) of a device as a function of the input target signal as the input signal is varied over the entire operating range of the system.

b. Optical Transfer Function (OTF): This is a general characteristic defined as the Fourier transform of the point spread function of the imaging device under test.

1.2 Limitations:

a. This procedure is limited to particular methods for observing the operational performance of infrared surveillance equipment. It does not consider testing of human factors, environmental testing, maintainability, and the transportability aspects of a particular infrared device.

b. The tests contained in this procedure are to be conducted as laboratory bench tests involving the major infrared sensors or items to determine the adequacy of the stated performance specifications. This type of testing is typically performed during the research and development (R&D) phase of testing, but is not performed by the Test and Evaluation Command.

c. If the infrared equipment to be tested is an integral part of another item of materiel, it should undergo "system" type tests to determine the adequacy of the overall system's performance.

2. FACILITIES AND INSTRUMENTATION

2.1 Facilities:

ITEM	REQUIREMENT
An Optical Test Facility	Used to make controlled laboratory measurements under closely controlled temperature and humidity conditions (see paragraph 2.2.1).
Field Ranges	Includes a Spatial Resolution Facility (SRF) and both active and passive IR target arrays. Positive sensor test vehicle time-space-position determination must be possible.

2.2 Instrumentation. All instrumentation used during testing under this procedure will have a current calibration certificate indicating that it meets the requirements outlined in MIL-STD-449D, paragraph 5.1.

2.2.1 The nature of the tests described in this TOP dictates that a sophisticated testing facility and highly specialized test equipment be employed. The Research and Development Technical Report ECOM-7034, "DOD Advanced Image-Evaluation Program", June 1974, specifies the instrumentation requirements, modular arrangement, and suggested test parameters.

3. PREPARATION FOR TEST

3.1 Planning. The test officer must assure himself that the test plan will sufficiently exercise the test item to accomplish the reasons for undertaking the test. For development tests (DT), the Independent Evaluation Plan (IEP) and the Test Design Plan (TDP) will usually outline the particular requirements to be included in the test plan. The assigned test officer will activate a project notebook for each test item, recording in it pertinent descriptive and technical information. The project notebook provides a narrative discussion of test conduct and results and is kept current for the duration of the test program. In addition, test planning encompasses a consideration of the potential foreign threat factors that will permit a realistic evaluation of the test item in a threat environment. Complete test planning requires that the test officer:

a. Prepare a test operations checklist using appendix A as a guide.

b. Develop specific safety requirements during test preparation to include:

(1) Guidelines for display of appropriate safety warnings in the test area.

(2) Procedures for training test personnel to properly handle infrared devices prior to test start.

(3) Provisions for eye examinations for all test personnel prior to test start and after test completion.

c. Brief test personnel on all aspects of the test program to include the purpose of the test and the precision requirements during test conduct.

d. Provide sufficient copies of operating instructions to all test personnel.

3.2 Facilities. Preparation of the test facilities to be used for the conduct of infrared equipment testing should include:

a. Adequate lead time for scheduling the test facilities that are to be involved.

b. Preparation of laboratory benches and floor space.

c. Adequate power distribution.

d. Assembly of tools, operating instructions, loads, and equipment-handling devices.

e. Ambient environmental conditions.

NOTE 1: The specialized equipment required for these tests may not be readily available to the test officer. The US Army Electronics Research and Development Command's Night Vision Laboratory, Ft. Belvoir, VA, has the instrumentation and computer facilities to conduct such tests.

NOTE 2: For systems performance tests of materiel incorporating infrared equipment, the US Army Electronic Proving Ground's Electro-Optical Test Facility has the instrumentation and facilities to conduct tests under ambient conditions and under controlled degraded conditions using aerosols and/or obscurants.

3.3 Test Item. In his preparations for test conduct, the test officer will insure that:

a. Subject to security provisions, a record of the test item nomenclature, its technical characteristics, its manufacturer, and its performance parameters are entered into the project notebook.

b. The test item is photographed from several perspectives to provide a nonambiguous visual identification and description of the test item.

c. The test item and all of its associated components are inspected for damage, deterioration, and obvious manufacturing defects.

d. The test item is in proper operating condition.

3.4 Instrumentation. In his preparations for test conduct, the test officer will insure that:

a. All test equipment and other instrumentation is scheduled and readily available for use during test conduct.

b. All test equipment is calibrated prior to the scheduled test start date and that calibration standards equal or exceed the standards stipulated in paragraph 2.2 above.

c. The heat sources used during testing have been calibrated and the masks employed have been properly adjusted.

4. TEST CONTROLS

All test controls are designed to insure validity of the test data. Reproducibility is one determinant of validity. The facilities, the test item, and the test instrumentation must be selected, treated, and documented so as to enable an independent investigator to repeat the test with an expectation of arriving at the same results. Some specific controls to consider are:

4.1. Facilities:

a. Appropriate safety warnings proclaiming the potential hazards of the specific infrared item under test should be prominently displayed at all entry points to the test facility.

b. The relative humidity within the test facility will be maintained between 40 and 60 per cent.

c. The indooor test facility's ambient temperature should not vary more than 1°C.

d. The test facility's line voltages, used to power the test item and associated instrumentation, should not vary more than five per cent from the mean.

e. The inside walls of the test facility should be painted flat black to minimize temperature aberrations and reflections.

4.2. Test Item:

a. The test item must be a representative sample of the item population.

b. The adjustments and operating procedures used for the test item must follow the instructions contained in the technical manual for the item or the manufacturer's operational instructions.

c. Except as directed by test procedures, the test item must not be moved, adjusted, or calibrated while comparative and reproducibility tests are in progress.

4.3 Instrumentation:

a. Applicable instrumentation will satisfy the standards for accuracy and stability as required by paragraph 2.2.1 above.

b. Instrumentation will be calibrated prior to test conduct.

c. The same instrumentation will be used throughout a particular subtest.

5. PERFORMANCE TESTS

5.1 Equipment Arrangement. For all subtests described, the general arrangement of the test item and instrumentation is as shown in figure 1. Specific set up instructions will vary with each test item. The four basic modules shown feeding data into the data processor and control facility are common to all measurements.

a. The first is the Target Source Module. Its function is to provide a well-known geometric-shaped input target with well-known spectral radiance (or luminance) characteristics and a well-known background.

b. The second module is the Collimator Module which is the lens assembly designed to transmit energy from the source background to the imaging system under test at infinite conjugate.

c. The third module is the system under test Positioning Module. It is able to center the objective lens of the imager under test in the collimated beam and align it with respect to the optical axis. It allows the system to be rotated about its nodal plane vertically and horizontally. Each test item will require a specific installation procedure. The test officer is responsible for developing the procedures, fixtures, and jigs to install the test item onto the positioning module.

d. The fourth module is the Receiver Module. It is designed to record and analyze the image presented at the display of the imaging system under test. It includes as a monitor either the human eye or a radiometric probe with a selection of apertures for collecting various records of the output image intensity as a function of position. This monitor is capable of x and y motion, as well as control along the optical axis for focusing. It is able to accommodate both monitors viewed with eyepieces and the larger monitors used for direct eye viewing. One further means of collecting information from the imaging sytem under test is by making electrical measurements at the video line. The video line measurements provide the ability to evaluate the increasing number of IR systems which are not supplied with displays. The above output receivers, with the exception of the eye, then transfer their analog or digital information to a computer for further processing and data printout.

5.2 Method:

5.2.1 Minimum Resolvable Temperature (MRT):

a. Center the objective lens of the test item on to the Positioning Module in the collimated beam as shown in figure 1.

b. Align the objective lens of the test item with its optical axis.

c. Optimize the system focus by using a near resolution-limited pattern at a high temperature difference in the Target Source Module.

d. Select a very low input frequency pattern (typically 1/20 Detector Angular Subtense [DAS]). This is a four-bar 7:1 aspect ratio pattern for the Target Source. The bars are oriented vertically in relation to the raster scan.

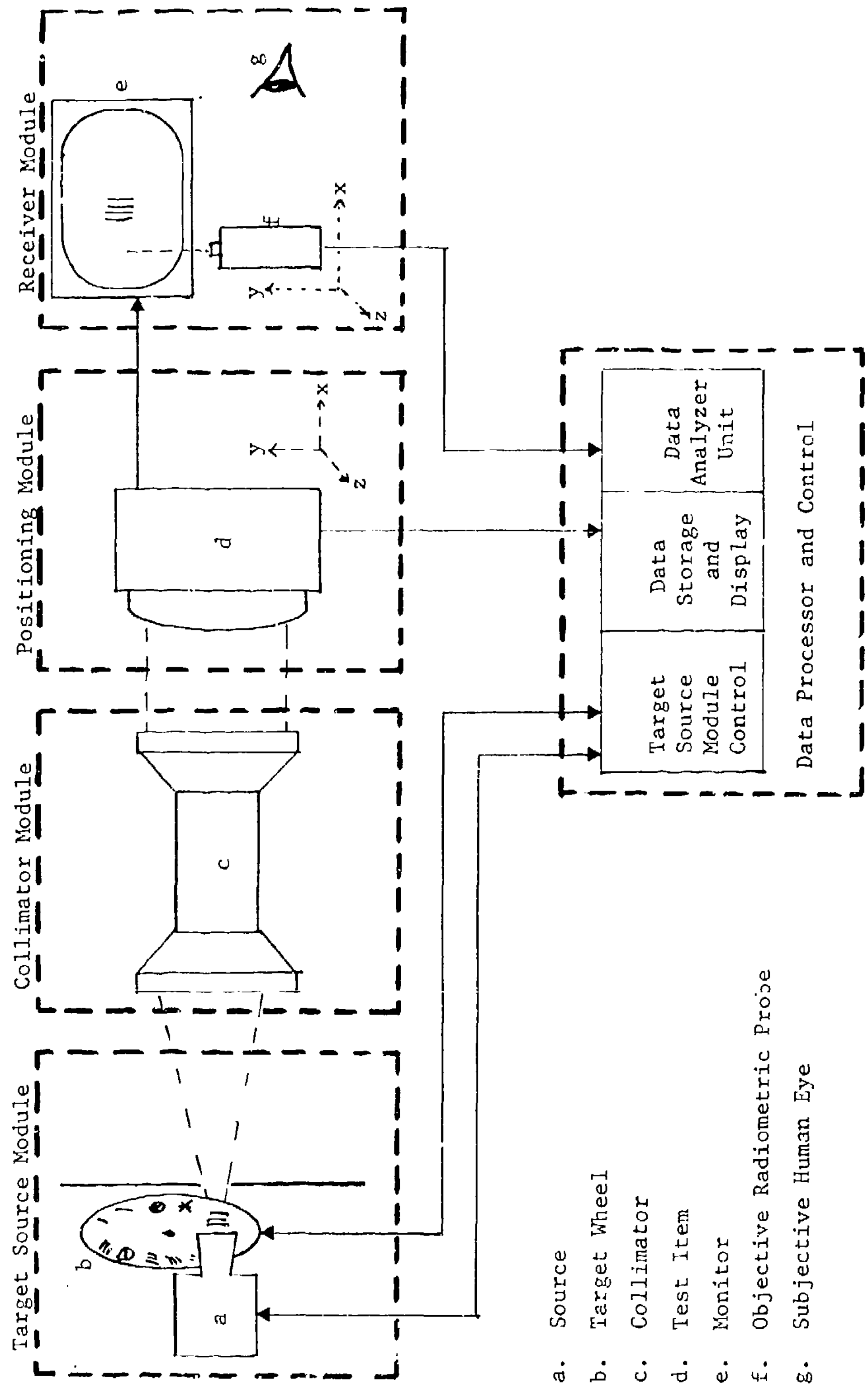


Figure 1 - Schematic of Major Modules for Infrared Image Evaluation

e. Determine the ambient temperature, ΔT, by changing the source temperature from below ambient to above ambient while noting the ability of the observer to discern the four black or white bars. After going from the last temperature at which the bars appear black (T_B) to the first temperature at which they appear white (T_W), the midpoint is calculated and labeled ambient (ΔT should read 0.0°K).

f. Optimize the brightness and gain control for the observer, and record the index settings.

g. Note and record the temperature difference between the ambient and the minimum temperature at which the four bars are resolved (this is the MRT for that spatial frequency). Record the spatial frequency used.

h. Continue the process, repeating steps e through g for successively higher spatial frequencies until the observer cannot resolve the four-bar pattern regardless of the temperature differences (normally at 10°KΔT is sufficient).

i. Repeat entire test with other observers and average the results.

NOTE: Do not disassemble the test item and instrumentation arrangement if other subtests are to be conducted.

5.2.2 Minimum Detectable Temperature (MDT). NOTE: If this subtest is the first test conducted, the test item must be installed and the system focused as outline in paragraph 5.2.1, steps a, b and c, prior to commencing this subtest.

a. Select a small aperiodic circular (or square) aperture as the target source.

b. Determine the ambient temperature as described in paragraph 5.2.1, step e.

c. Optimize the brightness and gain controls for the observer, and record the index settings.

d. Increase the temperature difference slowly until the observer first detects the target. Note this temperature difference (this is the MDT for that particular aperture).

e. Repeat the entire test with other observers and average the results.

5.2.3 Signal Transfer Function (SiTF):

a. Install the test item onto the Positioning Module as indicated in paragraph 5.1c.

b. Optimize the system focus by using a near-resolution limited pattern at a high temperature difference in the Target Source Module.

c. Select a circular aperture whose area subtends approximately one per cent of the field of view of the item under test. The background plate should fill the remainder of the field of view. This completes the Target Source Module.

d. Select a circular photometric probe whose projected size is large compared to a scan line and small enough to fall completely within the imaged aperture. This probe is to be installed in the Receiver Module; it becomes the monitor for the objective test, and its output is recorded as luminance in candela per square meter (cd/m^2).

e. Set the level and gain controls of the item under test to fixed values of interest.

f. Generate measurement data by increasing the input target temperature differential from below ambient to a temperature difference where the system reaches saturation. Record the luminance generated for specific temperature differentials on the data collection sheet.

g. Repeat step f at different gain settings while holding the level constant. Do this enough times to produce a family of curves (see paragraph 6.2.3).

h. Repeat step f at different level settings while holding the gain constant. Do this enough times to produce a family of curves.

5.2.4 Optical Transfer Function (OTF):

a. Install the test item onto the Positioning Module as indicated in paragraph 5.1c.

b. Select a variable width slit which is adjusted so that the angle subtended by the slit width to the item under test is five to 10 times smaller than the Detector Angular Subtense (DAS). This slit is installed in the Target Source Module and oriented vertically to the raster scan. The energy source is adjusted to insure the test item is operating in the linear portion of its SiTF curves.

c. Optimize the gain, level, and focus of the system.

d. Install appropriate optics and a radiometric probe in the Receiver Module. The probe must be visually and electronically aligned and positioned to insure peak focus and parallelism with the displayed slit image.

e. Scan the probe across the display perpendicular to the slit image. The probe output, or line spread function (LSF), is fed into the data processor. The LSF should be measured to a distance of at least 10 times the spread function width.

5.3 Data Required:

5.3.1 Minimum Resolvable Temperature (MRT): The following data are recorded on data collection sheet #1 during the conduct of the test:

a. Observer name

b. Ambient temperatures $\frac{T_W + T_B}{2}$

c. Spatial frequencies

d. MRT's (°C)

e. Brightness control index setting [non dimensioned (n.d.)]

f. Contrast control index setting (n.d.)

5.3.2 Minimum Detectable Temperature (MDT): The following data are recorded on the data collection sheet #2 during the conduct of the test:

a. Observer name

b. Ambient temperature $\frac{T_W + T_B}{2}$

c. Brightness control index setting (n.d.)

d. Contrast control index setting (n.d.)

e. Aperture size and shape (mm)

f. MDT (°C)

5.3.3 Signal Transfer Function (SiTF): The following data are collected from the test item and recorded on data collection sheet #3 during the conduct of the test:

a. System gain settings (n.d.)

b. System level settings (n.d.)

c. Ambient temperature (°K)

d. Temperature difference (ΔT)

e. Luminance (c/d m^2)

5.3.4 Optical Transfer Function (OTF): The data collected for the determination of the OTF is fed, real time, to the data processor, and need not be tabulated. However, to be a unique measure of the test item, it is essential that all measurement conditions are specified.

6. DATA REDUCTION AND PRESENTATION

6.1 Data Reduction:

6.1.1 Minimum Resolvable Temperature (MRT): The data are plotted in a format similar to that shown in figure 2. The high frequency asymptote is estimated, and the object space frequency (f_o) which represents ½ DAS is determined. The brightness and gain control index settings are recorded for test replication purposes only, and need not be reduced or reported.

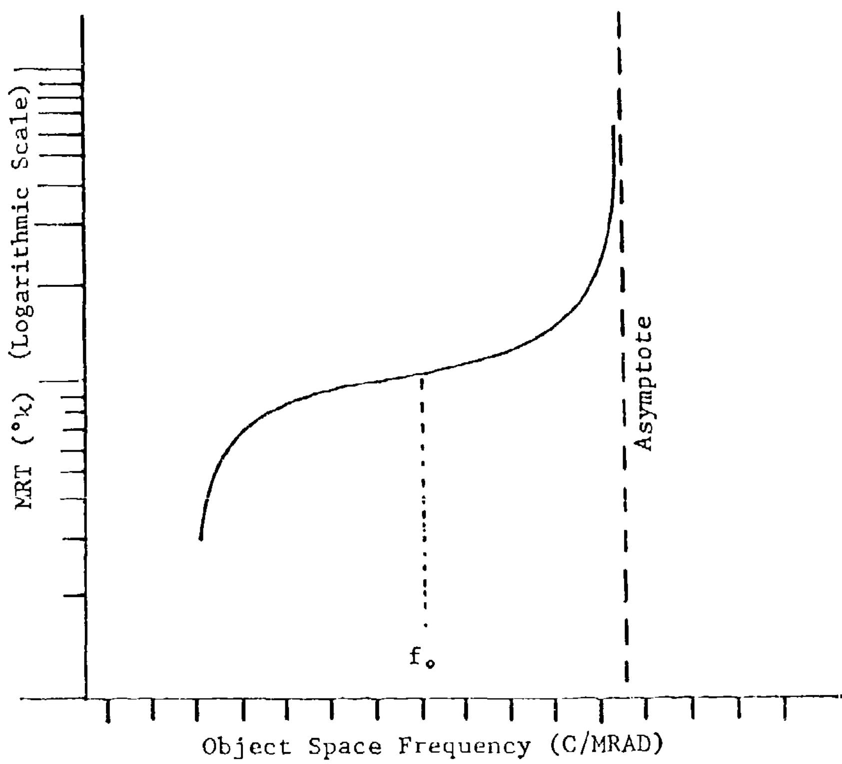


Figure 2 - Format for Presenting MRT Data

6.1.2 Minimum Detectable Temperature (MDT): The data need not be further reduced once recorded and averaged.

6.1.3 Signal Transfer Function (SiTF): The collected data require no further reduction. Computer programs are available, based on IEP/TDP and other test plan requirements, that can be used to produce, automatically, the family of curves discussed in paragraph 6.2.3.

6.1.4 Optical Transfer Function (OTF): The line spread function (LSF) generated by the probe is a convolution of the point spread function and the narrow slit target. Therefore, a Fourier transform of the LSF is performed by the computer program and presented graphically. Figure 5 illustrates examples of both the LSF and the resulting OTF after the Fourier transform.

6.2 Data Presentation:

6.2.1 Minimum Resolvable Temperature (MRT): The data are presented graphically; the abscissa representing the object space frequency (C/MRAD), the ordinate representing (in logarithmic scale) the MRT (°K). The high frequency asymptote and the object space frequency (f_o) which is ½ DAS are indicated (see figure 2).

6.2.2 Minimum Detectable Temperature (MDT): The MDT is presented in format similar to data collection sheet #2. The results of each observer and the average of all observers will be used for data presentation.

6.2.3 Signal Transfer Function (SiTF):

a. SiTF is presented in the form of two sets of families of curves similar to those shown in figures 3 and 4. Figure 3 presents the data in which the level is held constant and the gain is varied, while figure 4 presents the data in which the gain is held constant and the level is varied.

b. The key characteristics of interest concerning these curves are the range of slopes in the units of shades of grey per °K and the approximate level range in terms of K. The limiting output of luminance is also of interest.

6.2.4 Optical Transfer Function (OTF): The computer generated Fourier Transform of the LSF into the OTF is presented in a format similar to that shown in figure 5.

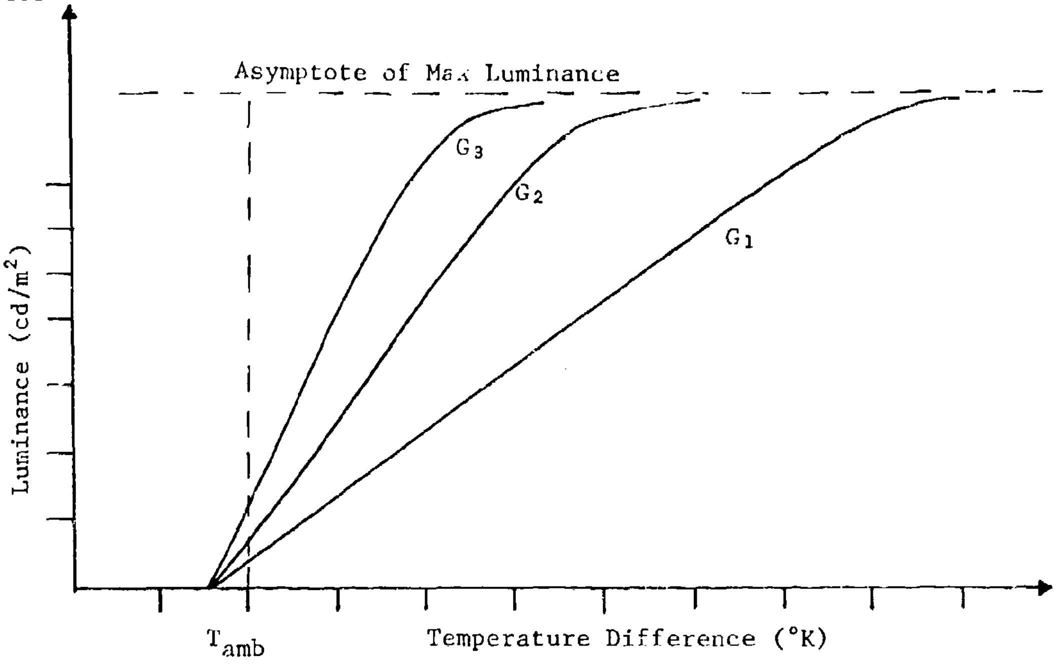


Figure 3 - Signal Transfer Function; Holding Level Constant, Varying the Gain

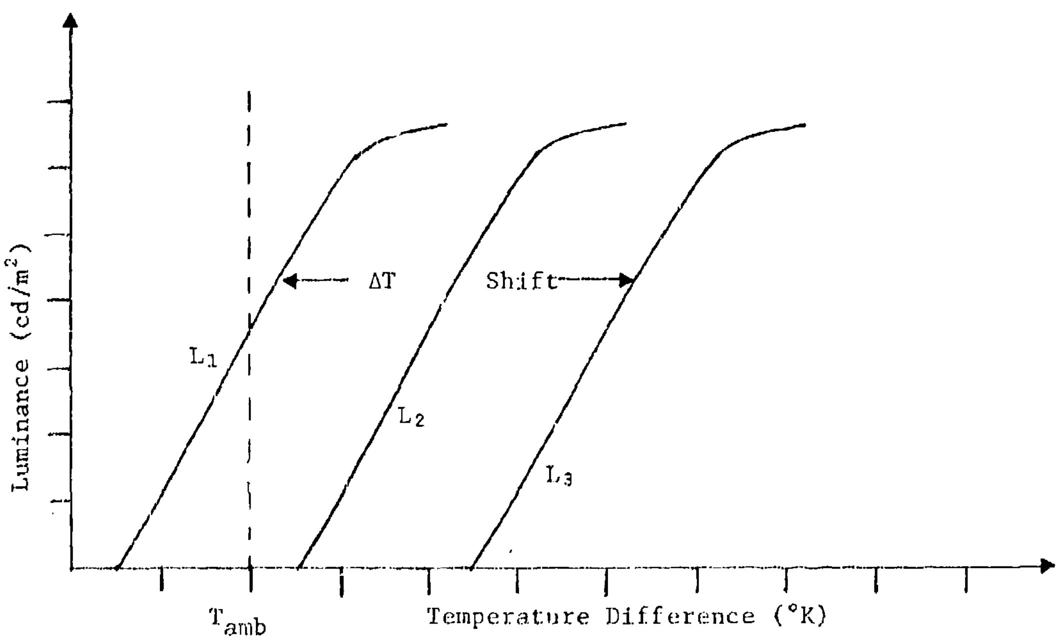


Figure 4 - Signal Transfer Function; Holding Gain Constant, Varying the Level

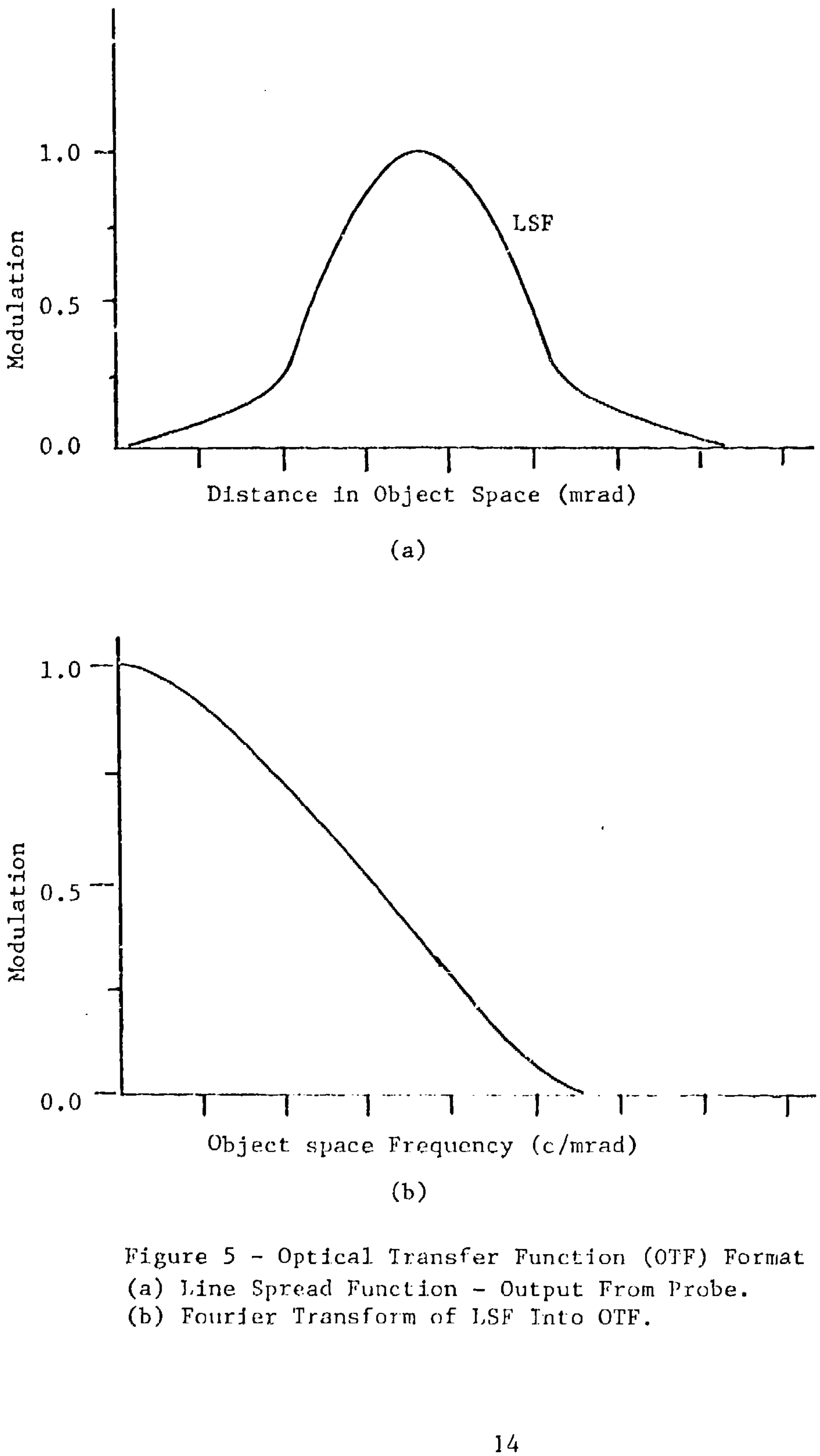


Figure 5 - Optical Transfer Function (OTF) Format
(a) Line Spread Function - Output From Probe.
(b) Fourier Transform of LSF Into OTF.

APPENDIX A

CHECKLIST FOR INFRARED TESTING

	INITIALS	
	Test Officer	Test Supervisor
Availability of appropriate documentation and authority for the conduct of the test program:	______	______
Initiate a project notebook:	______	______
Establish the project file:	______	______
Availability of appropriate references:		
Required Operational Capability (ROC):	______	______
Test Item Specifications:	______	______
Military Standards:	______	______
Test Operations Procedures:	______	______
Operating Manuals:	______	______
Coordination with test sponsor/contractor:	______	______
Are dates for desired test execution realistic?	______	______
Availability of test plan to all participants:	______	______
Coordination for necessary test support:	______	______
Identification of critical test issues:	______	______
Test facility conforms to specified standards:	______	______
Brief all test personnel:	______	______
Safety and eye protection considerations:	______	______
Instrumentation data have been recorded:	______	______
Instrumentation has been currently calibrated:	______	______
Calibration due date for all instrumentation will permit completion of testing:	______	______
Test item data recorded in project notebook:	______	______
Initial inspection performed:	______	______
Photographs taken of test item(s):	______	______
Equipment performance reports prepared:	______	______
Data collection sheets are complete:	______	______
Test report prepared:	______	______

APPENDIX B

DATA COLLECTION SHEET AND PRESENTATION FORMATS

DATA COLLECTION SHEET NO. 1

MINIMUM RESOLVABLE TEMPERATURE

Observer: ______________________

Brightness: ______________________

Contrast: ______________________

f	T_B	T_W	$\frac{T_W + T_B}{2}$	MRT

f	Spatial frequency
T_B	Last temperature when black bars are visible
T_W	First temperature when white bars are visible
$\frac{T_W + T_B}{2}$	Calculated ambient temperature
MRT	Minimum Resolvable Temperature

DATA COLLECTION SHEET NO. 2

MINIMUM DETECTABLE TEMPERATURE (MDT)

Observer: ______________________________

Aperture Size: ______________________________

Aperture Shape: ______________________________

Brightness: ______________________________

Contrast: ______________________________

T_B	T_W	$\frac{T_W + T_B}{2}$	MDT

T_B Last temperature when black target is visible

T_W First temperature when white target is visible

$\frac{T_W + T_B}{2}$ Calculated ambient temperature

MDT Minimum Detectable Temperature

DATA COLLECTION SHEET NO. 3

SIGNAL TRANSFER FUNCTION (SiTF)

Ambient Temperature: ______________________

Constant Level:			Constant Gain:		
Gain Setting	Temperature Difference	Luminance	Level Setting	Temperature Difference	Luminance

APPENDIX C

FLIGHT TESTING FOR SPATIAL RESOLUTION

The test requirements for IR sensors may dictate the use of the Spatial Resolution Facility (SRF) located at Ft. Huachuca, Arizona.

This facility consists of a flat concrete surface forming three wedges 678 feet long by 200 feet wide. One wedge is painted with aluminum horizontal and vertical bars for IR measurements; another with white bars on black background for photographic measurements; the third is painted with two shades of gray paint. Another part of the facility consists of an IR target array and radiation measurement instrumentation required to evaluate the thermal sensitivity and geometric resolution of a broad class of airborne IR surveillance systems. The target array consists of a series of active targets for short wavelength IR systems and a series of passive targets for mid to long wavelength IR systems. Target controllers provide for setting temperature differentials of one degree to 40 degrees centigrade. The canvas passive array consist of a 100-foot edge target for edge analysis and a series of six 40-foot by 40-foot panels providing a gray scale in the infrared spectrum. The emulsion coated canvas panels have been calibrated by the National Bureau of Standards.

The sensor being tested should be installed in the test bed aircraft and flown over the SRF at altitudes of 300, 500, 1,000, 2,000, 3,000, 4,000, and 5,000 feet, with a ground track parallel to the infrared leg of the facility. The test bed aircraft should also be flown at altitudes of 500 and 1,000 feet with a ground track perpendicular to the infrared leg of the facility.

These resolution flights should be made at various times during the day and night, and the target controllers and the active targets should be set for appropriate temperature differentials.

Record the time of day and following meteorological data for each flight:

1. Temperature

2. Wind Velocity

3. Atmospheric pressure

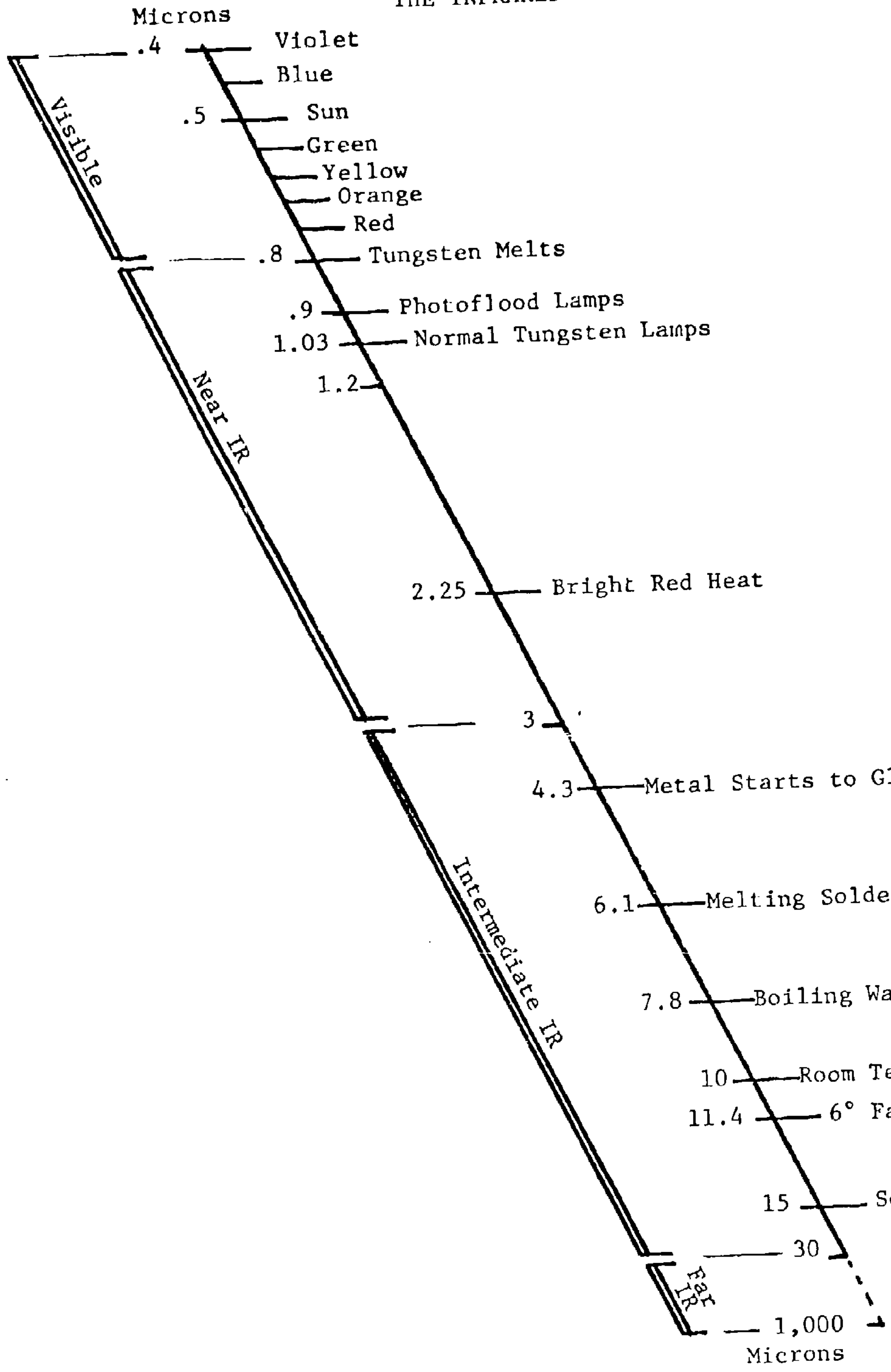
4. Relative humidity

5. Cloud cover

These tests are, by their very nature, inexact. They should, therefore, only be used in conjunction with the laboratory tests when conducted for test item evaluation purposes.

APPENDIX D

THE INFRARED SPECTRUM



APPENDIX E

REFERENCES

"DOD Advanced, Image-Evaluation Program (ARPA Order 1938 - Phase I Report)." Research & Development Technical Report ECOM-7034, U.S. Army Electronics Command, Fort Monmouth, NJ, June 1974

Graf, R., Modern Dictionary of Electronics. Indianapolis: Sams, 1977.

"Night Vision Laboratory Static Performance Model for Thermal Viewing Systems." Research and Development Report ECOM-7043, U.S. Army Electronics Command, Night Vision Laboratory, Fort Belvoir, VA, April 1975