Standard Software for Automated Testing of Infrared Imagers, IRWindows^{TM} in Practical Applications

Alan Irwin

Santa Barbara Infrared, Inc.
312A North Nopal Street
Santa Barbara, CA 93103

Robert L. Nicklin

Uncooled Infrared Imaging Products
Raytheon Systems Company
13532 North Central Expressway, MS 37
Dallas, Texas 75243

ABSTRACT

In the past, ad-hoc and manual testing of infrared imagers hasn't been a deterrent to the characterization of these systems due to the low volume of production and high ratio of skilled personnel to the quantity of units under test. However, with higher volume production, increasing numbers of development labs in emerging markets, and the push towards less expensive, faster development cycles, there is a strong need for standardized testing that is quickly configurable by test engineers, which can be run by less experienced test technicians, and which produce repeatable, accurate results. The IRWindows^{TM} system addresses these needs using a standard computing platform and existing automated IR test equipment. This paper looks at the general capabilities of the IRWindows^{TM} system, and then examines the specific results from its application in the PalmIR and Automotive IR production environments.

Keywords: infrared imagers, FLIR, infrared imaging, automated testing, IRWindows, PalmIR, Automotive IR, Automated MRTD, AutoMRTD.

1. INTRODUCTION

Automated FLIR (Forward Looking Infrared) measurement equipment provides the following benefits:

1. Removes human subjectivity from the measured data thus creating a reproducible measurement technique which can operate in a "round-the-clock" mode independent of operator skill or fatigue level.
2. Drastically reduces measurement test time by a factor of 10+, which lowers product and/or maintenance cost.
3. Increases product quality by measuring all infrared parameters, and statistically monitoring key performance parameters.

The problem with automated FLIR testing has traditionally been the ad-hoc preparation of the software systems, which requires specialized expertise and complex interfacing between the control of hardware actuators and sources, the electronic interface to the data collection system, and the computationally intensive data analysis software. Also, much of the equipment required has been expensive and specialized.

In an environment where system production is small and the ratio of trained personnel to production rates is high, then manual control, measurement, and data entry is often a reasonable alternative. However, increased production volume and the need to use more production and field personnel who are less well trained has increased the need for simple automation which can be quickly configured for specific testing requirements.

Raytheon TI Systems was faced with these concerns while developing the production line of their uncooled infrared cameras. Their solution was to use the IRWindows^{TM} FLIR test system as developed by Santa Barbara Infrared, Inc.

1.1 Santa Barbara Infrared, Inc. (SBIR)

SBIR manufacturers infrared test equipment for both component and system level testing. SBIR has developed the necessary software and hardware to accomplish automated FLIR testing. This software product is called "IRWindows^{TM}" (*IRWindows*). *IRWindows* is a relatively new product introduced in 1996. SBIR and Raytheon TI Systems have jointly participated in the product testing of *IRWindows*. As a result of this effort, product enhancements have been incorporated, which improve the *IRWindows* functionality to a sophistication level required for performing automated infrared system test and depot level testing.

1.2 Raytheon Systems Company (RSC)

RSC produces ground and air based infrared detection systems. The ground based infrared products consist of high performance "cooled" (detector) systems and medium performance "uncooled" (detector) systems. RSC has researched the use of automated infrared testing using *IRWindows* on the uncooled product line since September 1996. RSC has implemented the *IRWindows* measurement technology for use on the acceptance testing for PalmIR and Automotive IR (both commercial products). These two products' system level testing were automated using *IRWindows* during the second half of 1997.

Future product implementation on the remainder of the commercial and military product line is being planned; including the Mobile1 (commercial surveillance IR imaging system), the thermal weapon sight (W1000 series) and the Drivers Vision Enhancer (DVE). The implementation of the *IRWindows* measurement technology is also being developed for the Improved Bradley Acquisition System (IBAS), a high performance military FLIR, utilizing cooled, high resolution detector, as well as automated depot level testing. Military product testing is more stringent than commercial testing, therefore, a rigorous test plan must be completed to validate any new measurement approach from the baseline measurements currently being utilized. Research in automated uniformity measurements was also performed for DVE during the second quarter of 1997.

Successful implementation of the *IRWindows* measurement system is the result of lessons learned through research studies and measurement activities. This document describes the *IRWindows* hardware, measurement definitions and formulas, the test plan approach, results of correlation efforts, and the implementation of the uncooled product line and test plan results.

2. *IRWindows* HARDWARE, MEASUREMENT DEFINITIONS, AND FORMULAS

2.1 Measurement Hardware

The automated measurement system (see Figure 1) consist of a unit under test (UUT), an infrared target projector, a data acquisition system, and a personnel computer (PC) containing the control, measurement, and analysis software *IRWindows*. The infrared target projector consist of a reflective (two mirror) collimator, a computer controlled blackbody controller and target wheel, a blackbody, and the various opaque targets. The data acquisition system consist of a commercial RS-170 compatible digitizer. The computer measurement system is customized to measure key parameters of an infrared system, and along with pre-defined constants is capable of estimating the relative performance normally described by a trained human observer. The *IRWindows* software also allows an operator to configure the parameters necessary to run a particular measurement, or load parameters from a previous test. *IRWindows* has a graphical type interface, and is easy to control and modify the measurement parameters. Test results are displayed to the operator in a tabular or graphical display, or can either be exported to a text file or dynamically linked to a master control program. And (optionally), entire test plans can be predefined as macros and run by clicking a button from an operator's menu.

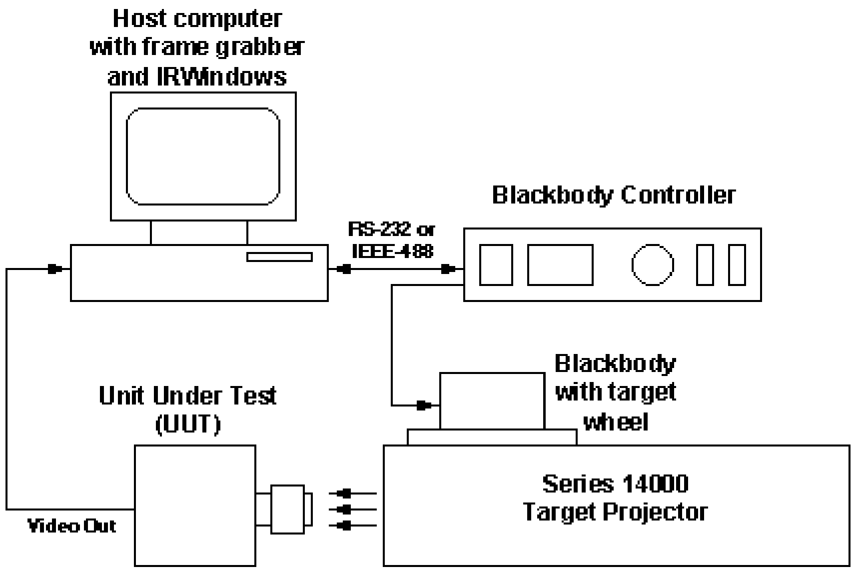

Figure 1 Automated IR Measurement System

2.2 Measurement Theory and Technology

Various types of performance parameters are used to measure the performance of a FLIR's ability to detect thermal radiation of a real world scene. Infrared electro-optical (EO) measurements include; the signal transfer function (SiTF), small area noise equivalent temperature difference (NETD), small area uniformity (sigma divided by the mean), large area NETD, large area uniformity, modulation transfer function (MTF), minimum resolvable temperature difference (MRTD); and automated minimum resolvable temperature difference (Auto MRTD). Figure 2 (at the end of this section) is a graphic flow diagram of how *IRWindows* performs Auto MRTD. Each test produces a performance parameter on its own, and the diagram shows how the elements are incorporated into the Auto MRTD. Each of the tests is discussed in the following sections (more rigorous definitions can be found in Holst[1], Dudzik[2]).

2.2.1 Signal Transfer Function

The signal transfer function (SiTF) determines the responsivity of an infrared imager. The SiTF provides information on gain, linearity, dynamic range and saturation. The SiTF is the slope of the output voltage versus the differential temperature curve. The SiTF responsivity curve is typically shaped as a sideways "S". The SiTF measures the variation in the signal difference between the target and its background over a series of differential temperatures (positive and negative). The SiTF is an automated measurement using the *IRWindows* measurement system. The SiTF is measured by acquiring data from an area on each side of a "large area" target. The video frame is captured using the frame grabber electronics. The infrared imagers' output variation is sensed as a voltage difference between the target image area and its background area. Thus, the target and background signal are acquired, and a voltage difference corresponding to the temperature difference is obtained. The differential temperature of the blackbody controller is then commanded to the next temperature value, and the software obtains another data point on the SiTF curve. A minimum of two data points is required, however, at least five data points is recommended. After completing all the pre-programmed differential temperature measurement points, *IRWindows* calculates the slope of the line, tangent to this curve to be the SiTF value. Frame averaging may be utilized to smooth out signal (temporal) variations during the SiTF measurements, however, this is dependent on the size of the measurement area utilized. If the measurement area is large enough, this tends to sufficiently average out the temporal variations of the signal. Conversely, if the measurement area is small some amount of frame average may be necessary to eliminate temporal noise effects.

2.2.2 Noise Equivalent Temperature Difference Measurement

The noise equivalent temperature difference (NETD) test measures the temperature difference that produces a peak signal-to-noise ratio of 1 (or unity) under equal (or flood) illumination. The NETD measurement is an excellent diagnostic indicator of system sensitivity because it verifies optimum system performance.

NETD is determined by measuring the zero-signal noise, computing an RMS and dividing by the SiTF. *IRWindows* isolates the high frequency component of the noise by removing fixed pattern (low frequency) noise from a captured image. The blackbody temperature for this measurement is usually set to 0° delta temperature. The NETD measurement can utilize other source temperatures (besides 0° delta T). This is usually for special uniformity tests, which can simulate environmental conditions or actual "real world" imagery. Other variations of noise measurements can be implemented by *IRWindows,* which do not remove the fixed pattern low frequency noise. This has advantages when measuring uncooled focal plane arrays, which may have varying amounts of fixed pattern (describe as "chicken wire") noise. Since this noise interferes with the trained observer's ability to perform manual system performance measurements, it should be included in the function, which predicts the Auto MRTD measurement. This type of noise measurement is evaluated using a small area block, approximating the size of the bar target used in the manual performance (MRTD) measurement.

The large area noise (uniformity) measurement analyzes a portion of the field of view (FOV) for blemishes, blotches, and shading effects, which may be distracting to the observer. *IRWindows* can be configured to perform this measurement. Uniformity is a measure of the luminance (or intensity) level at each point within the designated areas on the display as compared from the total average luminance value. Frame averaging can be used to reduce temporal noise in order to match an observers real world scene interpretation (this is somewhere between 3-10 frames and is dependent on the person and the amount of scene movement). The mean and standard deviation of the pixels in the target area can then be calculated from the selected area to be measured. Uniformity can be calculated by dividing the standard deviation of the pixels in the target area by the mean. Multiple small areas may also be measured within a single frame. However, large area uniformity (and noise) is obtained by including the entire FOV.

2.2.3 Modulation Transfer Function

The modulation transfer function (MTF) is a measure of how well the system will reproduce the scene. The highest spatial frequency that can be reproduced is the system cutoff or Nyquist frequency.

The MTF is calculated from an edge input, which is differentiated to obtain a line spread function (LSF). A Fast Fourier Transform (FFT) is performed on the LSF to obtain the frequency values. The frequency output is normalized to get the 0% to 100% modulation values. *IRWindows* performs all these calculations on captured video data, usually averaging a large number of frames to reduce high frequency noise effects on the calculations. Provisions for removing some well characterized noise sources (specifically the pedestal and component sample smoothing) are also included in the calculations.

2.2.4 Manual Minimum Resolvable Temperature Difference

Observer detection of standard four bar targets is an industry-wide method of measuring infrared image quality and overall system performance. The minimum resolvable temperature difference (MRTD) is a subjective measurement, which depends upon the ability of the observer to resolve detail, and is inversely related to the MTF. The measurement software controls the target positioning, the starting temperature, and data recording/analysis. These are automated features which reduce the overall test time for this manual test.

2.2.5 Automated MRTD

The automated minimum resolvable temperature difference (Auto MRTD) is based on automated measurements and calibrated correction factors which incorporate an observer's effect on resolving each target. After calibration, Auto MRTD does not require four bar targets or a trained observer. Vertical or horizontal measurements may be obtained providing the MTF has been performed in that axis.

The calibrated correction factors are called $\mathbf{K_f}$, or K factors. Once calculated for a product line, then new MRTD values can be calculated for an individual system from its measured NETD and MTF. The Auto MRTD formula is:

$$MRTD_f = \frac{K_f \, NETD}{MTF_f}$$

To get these results, an NETD test and an MTF test need to be performed for each UUT.

The K factors are derived from the formula:

$$K_f = \frac{MRTD_f \, MTF_f}{NETD}$$

where the MRTD value refers to the results from a manual MRTD test performed at the target spatial frequency, *f*. K factors for production testing are typically averaged using several units with several trained observers. K factors can be rechecked periodically to ensure reliable measurement predictions are maintained through the production lot. These K factors are stored in the *IRWindows* configuration file (for a further discussion of Automated MRTD, see Holst[1]).

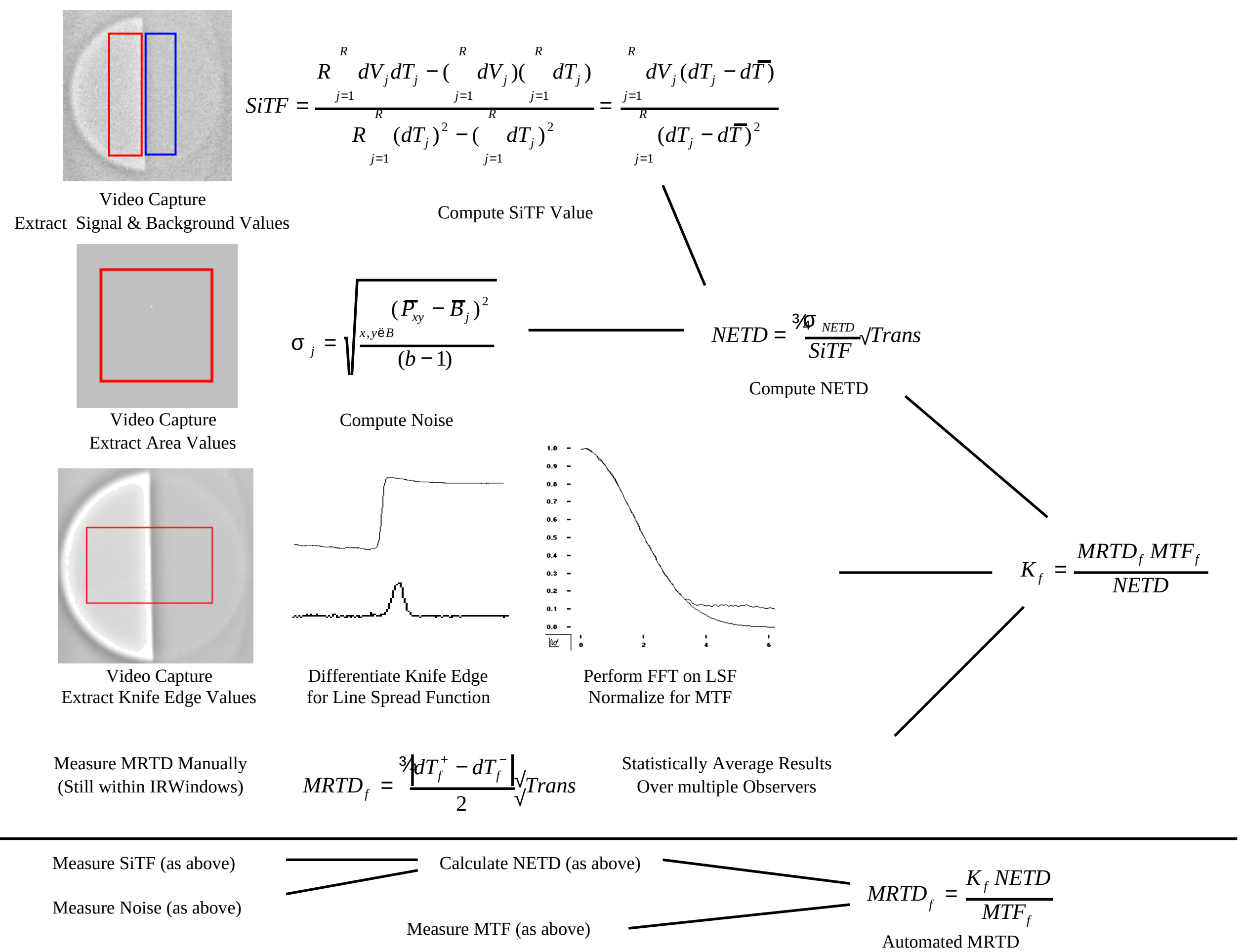

Figure 2 IRWindows Calculation Dependencies

2.2.6 Test Configurations, Macros, and Data Files

An *IRWindows* configuration file is a customized data input file, which describes parameters unique to an installation. In addition, each test procedure (SiTF, NETD, MTF, etc.) can have multiple configurations, each of which can be executed as a specific test. For instance, one SiTF configuration could measure the signal 10 times at 0.1 ^{o}C intervals, and a different configuration could perform the SiTF taking 5 measurements at 0.5 ^{o}C intervals. The configuration file includes:

- FOV of the sensor
- Thermal source parameters
- Target wheel parameters
- Pass/fail criteria

- K factors
- Test configurations and macro programs
- Collimator transmission factor

This test configuration file is controlled by the users resident system engineering staff and/or quality organization. The creation of this file is based on UUT parameters, correlation studies, and production results.

A test macro is a group of test configurations which are executed in sequence. This is a way of encoding a complete test procedure which could involve many individual tests. These macros can include:

- UUT setup such as gain and focus adjustment
- UUT alignment utilizing the coordinate measurement software
- SiTF test
- Noise test
- Large area test
- MTF test
- Manual MRTD test
- Auto MRTD test
- Other tests as developed by SBIR

An event log displays testing and source control activity. Test results are displayed graphically, in tabular format, and can be exported or combined into a summary sheet. Pass/fail criteria can be compared to test results for decision making. Customized data sheets can be created by using the file export commands in conjunction with the Excel or any Windows™ application. Test results are collected into files which can store all the results from individual UUT's. These results files (called UUT files) can be loaded back into *IRWindows* for further data reduction at any time.

3. TEST PLAN AND CORRELATION MEASUREMENTS

A test plan was created for the purpose of validating the performance of *IRWindows*. This test plan was conceived from discussions held with personnel from the US Army Night Vision and Electronic Sensors Directorate (commonly called NVL). NVL is a customer for the RSC uncooled military product line. This test plan is shown in Figure 3. The test plan, simply stated, proves how well the measurement system predicts the MRTD as compared to a trained human observer. Various test are used to degrade, improve, and alter the performance of the infrared imager. Then the manual MRTD is compared with Auto MRTD. Additional correlation measurements are also performed to determine how accurate the NETD and MTF measurements are as compared to the existing methods of measurement. Although it is important to always predict the MRTD correctly, it is more important to never "pass" (predict a lower MRTD value) on a system which is in question of failing its specification. However, if a system does not meet specification it is less important to know exactly how bad it is, and general ranges may be acceptable.

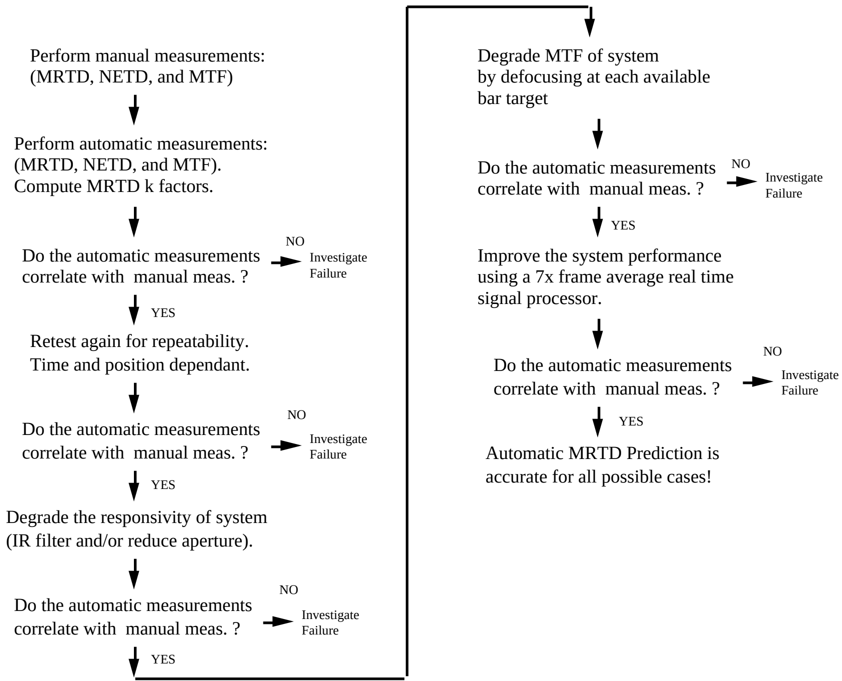

Figure 3 Auto MRTD Measurement Test Plan

3.1 Correlation Measurements

The process of correlating a new measurement tool involves performing established measurements and comparing the results against the new technique. This is more important when implementing the new measurement tool on an existing product.

3.1.1 Existing NETD Measurement Techniques

RSC has utilized several methods for the measurement of NETD. Some of these methods include: (1) the manual method, (2) the image evaluation lab (IEL) method, and (3) the IBAS method.

The manual method utilizes the following formula:

$$\frac{(\text{delta temperature x collimator transmission factor})}{(\text{signal variation / 6 sigma noise})}$$

or,

$$\frac{(\Delta T \times K)}{(S/N_{p\text{-}p}/6)}$$

where,

ΔT = delta temperature of blackbody source.
K = collimator transmission factor
S = Signal variation between background and source (signal) in volts. The measurement is made using the peak to peak technique. Frame averaging is required to increase measurement accuracy; however, averaging tends to attenuate signals, so too much averaging invalidates the result.
$N_{p\text{-}p}/6$ = 6 sigma noise - the peak to peak noise is measured on a small area of the background then divided by 6 to compute the 6 sigma noise component.

The target needs to be large enough such that MTF degradation is not a factor.

The IEL method was developed by the RSC image evaluation laboratory (IEL). This method closely matches the algorithms utilized by NVL. The IEL technique utilizes a computer (programmed with a customized Lab Windows program) which interfaces with a Tektronix sampling oscilloscope. The signal voltage, blackbody differential temperature, and the collimator transmission factor are entered into the IEL computer program. The signal voltage is determined manually off the video output using the digital oscilloscope from a single video line, averaged 256 times. Individual noise measurements are obtained from sequential video lines. Each noise measurement is an RMS noise measurement. The program then calculates an average NETD based on all the video lines measured.

The IBAS NETD measurement method utilizes the following equation and methodology:

$$NETD = \frac{(\Delta T \times \tau_{coll} \times Noise_{RMS})}{(Signal_{AVG} - NOISE_{AVG})}$$

where:

ΔT = Target to background temperature difference (5°C)
τ_{coll} = Transmission of collimator
$Noise_{RMS}$ = RMS of (10 frame average -1 single frame)
$Signal_{AVG}$ = Average of signal in 1 single frame
$NOISE_{AVG}$ = Average of Noise in 1 single frame
Note: The 1 single frame is not part of the 10 average

The US Army Night Vision and Electronic Sensors Directorate method is described in the paper by Bell and Hoover[3].

The uncooled detector factory's test station measures NETD using an automated process and is similar to the IBAS technique.

3.1.2 MTF Correlation Measurements

The RSC uncooled baseline manual MTF measurements is performed using a sampling oscilloscope with the frame averaging function set to around 100. Four bar MRTD targets are presented to the sensor. Video scan lines are adjusted to be in the center of the bar target. The peaks and valleys of the bar target are then measured. A single peak value is determined by averaging all the peaks and a single valley value is determined by averaging all the valley measurements. The following formula is then utilized:

$$MTF = \frac{(V1-V2) x \pi}{(V1+V2) x 4}$$

where:

V1 = average peak measurement
V2 = average valley measurement

The $\pi/4$ is a correction factor to convert this contrast transfer function to a true MTF result. This factor is applied only for targets at 1/2 fo. It should not be used for 1/4 fo targets (lower frequencies).

Other automated MTF measurement techniques are performed using a slit (smaller than the detector instantaneous FOV) illuminated using a high temperature source. The RSC uncooled detectors are currently tested using this (slit target) approach as does the US Army Night Vision Lab system test facility . A video scan line is sampled across the slit target, averaged, and then an FFT is performed on the measured signal. The disadvantage of this approach is the need for a precision slit (for each sensor's FOV) and the availability and increased time to settling of a high temperature blackbody source.

3.1.3 Manual MRTD correlation measurements

The Manual MRTD measurements made by *IRWindows* and NVL are virtually identical. Both assume a trained observing is determining the resolution threshold by making small changes to the differential temperature. The only difference is that *IRWindows* measures the "white hot" (source plate warmer than target cutout) temperature before the "black hot" (source plate cooler than target cutout) temperature, and some programs at RSC (but not all, it varied) measured "black hot" first. Comparison of the measured results were consistent.

3.2 Results of Correlation Measurements

The results of the correlation measurement process was subdivided into initial, PalmIR, and Automotive IR phases.

3.2.1 Initial Measurements

The initial measurements were performed in the first half of 1997 using a variety of uncooled infrared imagers over the course of the initial studies (9° FOV weapon sight, 12° FOV Nightdriver products, 15° FOV box camera, 12° FOV Mobile I system, and a 15 ° FOV *TRP* prototype system). These early tests allowed the *IRWindows* system to be configured in a fashion which provided basic correlation with manual methods. The study utilized individuals who performed the manual measurement, the IEL method, as well as the *IRWindows* method. The results of this study showed that the IEL method produced higher than expected results as compared to the manual method, and that the SBIR correlated with a 4 frame average. The *IRWindows* RMS (isolate high frequency) noise measurement was later tested and was found to correlate with the IEL results. These results also showed that the Auto MRTD predicted optimistic results when the system was purposely degraded (by defocusing and aperture limiting). Further testing using the MTF algorithms, enhanced with offset and smoothing operators, improved the test plan performance, but not to the expected level of providing foolproof test results. It would, however, provide an accurate indication of a degraded system.

3.2.2 Implementation of the Uncooled Product Line

The automated infrared test measurement process was implemented in 1997 for the PalmIR and the Automotive IR commercial products. Various NETD and MTF correlation studies were performed during 1997, which made the implementation of this technology possible. A uniformity study was performed for the DVE program to investigate the feasibility of implementing a non-subjective technique for measuring the large area uniformity. The results of this study are discussed in a separate report. The Mobile1 (commercial) and the Drivers Vision Enhancer (military) applications are planned to be implemented during 1998.

3.2.2.1 PalmIR Implementation

PalmIR is the lowest cost commercial infrared imager sold by RSC to date. PalmIR is a hand held, battery powered system designed for industrial, security, and inspection applications. PalmIR utilizes a commercial black and white, camcorder video display (viewfinder). This viewfinder is tested as a sub-assembly by the display's manufacturer. A decision to perform automatic measurements on the video output was justified because most product failures arise from within the infrared imager, and not from the display. In addition, the display is tested through a visual verification before final shipment is made.

PalmIR validated 50 units using the manual and automated MRTD measurements. The Auto MRTD K factors were determined by averaging the results from the initial 10 measurements, then were slightly modified during the remaining units to achieve an acceptable error margin between the manual and Auto MRTD measurements. A complete test plan analysis was not completed due to early implementation problems. However, an MTF and NETD absolute correlation effort was performed. The *IRWindows* Auto MRTD was optimized for successful implementation by ensuring the lens was at optimum focus before performing the automated testing. The use of the trained observer made this technique possible even though detailed manual testing is not required. This visual inspection would be necessary to ensure product quality. Accurate sensor positioning is required to ensure repeatable/reliable measurements. This is accomplished using the *IRWindows* coordinate measuring system and an azimuth/elevation sensor positioning system. Table I is a summary of the Auto MRTD accuracy. The PalmIR absolute average percent deviation between the manual MRTD and Auto MRTD for the three target sizes are 10, 7, and 17% (11% average). Table II is the list of the K factors used for the Auto MRTD. Figure 4 shows the deviation (MRTD - AutoMRTD) measurements for each target's spatial frequency, as computed from 22 measurements. The use of the AutoMRTD measurement technique has been successful and proven to be a valuable tool in achieving the high rate production of the PalmIR product.

Table I PalmIR Auto MRTD Prediction Accuracy

Target (cy/mr)	Spec. Value (°C)	manual - Auto MRTD (minimum)	manual - Auto MRTD (maximum)	manual - Auto MRTD (average)	manual - Auto MRTD % deviation (minimum)	manual - Auto MRTD % deviation (maximum)	manual - Auto MRTD Absolute deviation (average %)
0.19 (1/4 fo)	0.09	-0.019	0.011	-0.004	-21%	12%	10%
0.38 (1/2 fo)	0.18	-0.039	0.046	0.000	-22%	26%	7.0%
0.761 (fo)	0.50	-0.221	0.28	-0.042	-44%	56.0%	17%

Table II PalmIR K Factors

Target	K factors
1/4 fo	0.296
1/2 fo	0.397
fo	0.2

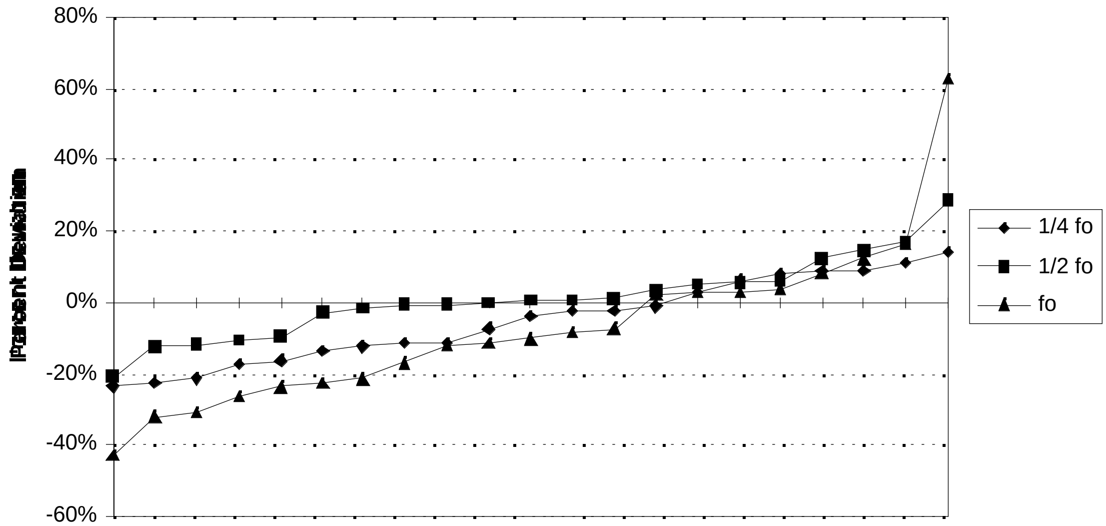

Figure 4 Difference between manual MRTD and AutoMRTD as a percentage of specification

3.2.2.2 Automotive IR Implementation

The Automotive IR infrared imager is the next generation uncooled automotive product. It is designed to be installed "under the hood" of an automotive vehicle. This product is being designed to be the lowest cost infrared imager with manufacturing cost to be below the $1,000 level. The display utilized for this product is a "heads up display", which is presented to the driver in the lower portion of the windshield. The use of an automated measurement system will be required to meet the production rates, system cost, and product quality. Automotive IR validated 18 units using the manual and Auto MRTD measurement technique. The test was performed similar to PalmIR in that the video signal was analyzed (not including the display). New *IRWindows* MTF software algorithms (developed as a result of the IBAS testing) was utilized on this system implementation. Several failures were indicated using the Auto MRTD, which surfaced real problems (focus & or noise). During the limited production run of 50 units, several false failures were manually re-tested (on the single target which failed) to allow the system to pass the specification. Accurate sensor positioning was also required to ensure repeatable/reliable measurements. This was accomplished using the *IRWindows* coordinate measuring system and an azimuth/elevation sensor positioning system.

Table III is a summary of the Auto MRTD accuracy. The Automotive IR absolute average percent deviation between the manual MRTD and Auto MRTD for the three target sizes is 6.7, 13, and 15.3% (or 11.7% average). Table IV is the list of the K factors used for the Auto MRTD. Figure 5 shows the deviation (MRTD - AutoMRTD) measurements for each target's spatial frequency, as computed from the 18 measurements.

Table III Automotive IR Auto MRTD Prediction Accuracy

Target cy/mr	Spec. Value (°C)	manual - Auto MRTD	manual - Auto MRTD	manual - Auto MRTD	manual - Auto MRTD	manual - Auto MRTD	manual - Auto MRTD

		(minimum)	(maximum)	(average)	% deviation (minimum)	% deviation (maximum)	Absolute deviation (average %)
0.19 (1/4 fo)	0.08	-0.019	0.007	-0.004	-24%	8.7%	6.7%
0.38 (1/2 fo)	0.16	-0.046	0.042	0.002	-29%	26%	13.0%
0.761 (fo)	0.45	-0.137	0.144	0.000	-30.4%	32.0%	15.3%

Table IV Automotive IR K Factors

Target	K factors
1/4 fo	0.193
1/2 fo	0.275
fo	0.15

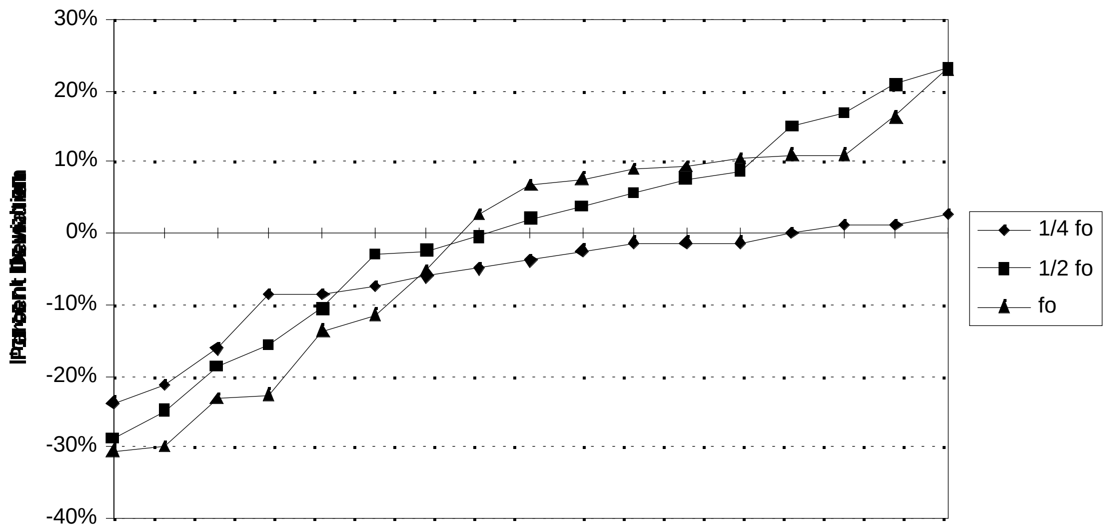

Figure 5 Difference between manual MRTD and AutoMRTD as a percentage of specification

4. CONCLUSIONS

The *IRWindows* software, when properly implemented, provides an accurate automated infrared MRTD measurement. This measurement has acceptable regions of uncertainty, which correlate equally with manual MRTD measurements (especially when operator fatigue or inexperienced operators are introduced). It is cost prohibitive to manually measure MRTD on systems with a high rate of production. Although a significant amount of non-recurring engineering has been spent on perfecting the measurement results obtained by *IRWindows,* RSC believes the pay off in increased product quality and lower production cost is worth the expenditure. Future improvements of *IRWindows* may have adaptive mechanisms to shorten the implementation cycle time and make alignment less critical. And, as was mentioned previously, future implementations on the remainder of the commercial and military product lines are being planned.

5. FURTHER *IRWindows* DEVELOPMENT

In addition to the RSC installations, *IRWindows* is being installed and utilized in a variety of facilities for both production and development purposes. Further releases of this product will be introducing additional capabilities, including capture of digital camera data streams and additional test procedures such as 3D Noise and component (detector) level testing.

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Further IRWindows information:

SBIR
Email: irwin@sbir.com; WWW: http://www.sbir.com; Telephone: (805) 965-3669; FAX (805) 963-3858

RSC
WWW: http://www.raytheon.com/nightsight; Telephone: (800) 990-3275