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A Unified Taxonomic Approach to the Laboratory Assessment of Visionic Devices (Reprint)

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Warfighter Performance and Health Division

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A unified taxonomic approach to the laboratory assessment of visionic devices

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ABSTRACT

The increased usage of visionic devices necessitates the development of a unified approach to testing and evaluation of such devices. A NATO working group was established to achieve this goal. This presentation describes a taxonomy to classify a given visionic device (based on optical design and display type) and to recommend specific test parameters that should be measured to ensure planned operational performance is delivered in the final product.

Keywords: visionic device, optical measurement, taxonomy, image intensifier, head-mounted display

1. INTRODUCTION

Today's military aircraft are extremely complex, agile and fast. They operate at heights from tens of feet (or meters) to tens of thousands of feet (or meters) above ground level. Pilots of these aircraft require instantaneous and continuous information about the aircraft's status and of the environment, both close-in and beyond visual range. While the operational speeds and environments may be different, the information requirements for drivers of mounted vehicles and for dismounted soldiers are generally the same and equally demanding.

To provide the increasing amount of data and imagery needed for today's warfighter, devices commonly known as helmet-mounted displays (HMDs) have been developed. The HMD can display information such as terrain imagery, the presence of obstacles, the position of friend and foe, and/or the status of the aircraft or vehicle. Overall, the HMD can enhance situational awareness and provide both tactical and strategic data without requiring the soldier to physically redirect head position line-of-sight and/or the physical direction of the aircraft or vehicle.

Integral to the successful development and fielding of HMDs is developing and implementing an integrated test and evaluation program to ensure that the HMD meets design specifications and does not degrade user performance in the field. The tests that define HMD performance are usually performed both in the laboratory and in operational field environments. Laboratory tests can be categorized as optical, biodynamic, and acoustical. Operational field tests are task driven and are dependent on mode of operation, i.e., aircraft, ground vehicle, or dismounted warfighter.

Under the auspices of the North Atlantic Treaty Organization's (NATO's) Research and Technology Organization (RTO) panel on Human Factors and Medicine (HFM), a technical working group, HFM-091/RTG-027 "Common methodological basis for evaluation and testing of visionic devices," has been established. The goal of the working group is to create a document that will provide guidelines for the selection and implementation of various test and evaluation methodologies for measuring the performance of prototype and production visionic devices. For the purpose of the working group, the more common usage terminology of HMD has been replaced with the more generic term of *visionic device*.

While the overall performance of a visionic device can be fully defined only by a combination of biodynamic, acoustical and optical parameters, the working group limited its scope only to the optical performance issues. This paper presents a proposed unified approach to the selection of test parameters and the implementation of test methodologies that address *laboratory* optical performance. The approach involves the development of a decision matrix that may be used as a guideline for selecting relevant test parameters for a specified visionic device, based on the optical design approach and display technology.

2. BACKGROUND

2.1 Visionic Devices

Within the Terms of Reference of the HFM-091/RTG-027 working group, visionic devices are defined as equipment that provide the warrior a visual pictorial image of the surroundings through various kinds of electronic sensors, augmented or not with symbolic information. In a more recognizable form, such a device is a compact electro-optical device, usually mounted on or built into a helmet, and is used to project data and/or a scene directly into the visual field of the user. It allows the warfighter to view the outside environment simultaneously with important navigational, tactical, or strategic information and other data. In aircraft or ground vehicles, the device may be combined with a head tracker; so that images displayed in the device can be made to change as the soldier's head moves, changing the line-of-sight.

Visionic devices have been fielded for some time in aviation. Examples include numerous versions of the U.S. Army's Aviator's Night Vision Imaging System (ANVIS), the Integrated Helmet and Display Sighting System (IHADSS) used on multiple models of the AH-64 Apache helicopter, the TopOwl system (Thales-Avionics, France) that has been adopted for multiple rotary-wing aircraft worldwide and the Panoramic Night Vision Goggle (PNVG). See Figure 1.

Figure 1. The ANVIS (top left), IHADSS (top right), TopOwl (lower left) and the PNVG (lower right) visionic devices.

Ground vehicle applications include the Combat Vehicle Crew Helmet-Mounted Display (CVCHMD) used on the U.S. Army's M1A2 tank and the Nomad Augmented Vision System used on the U.S. Army's Stryker (Figure 2). An example of a visionic device planned for use by dismounted soldiers is the Land Warrior system (Figure 3).

Figure 2. The Nomad visionic device.

Figure 3. The Land Warrior visionic device (HMD) for dismounted soldiers.

Visionic devices are touted as providing a number of advantages. In aviation applications, these devices provide pilots the ability to maintain situation awareness and knowledge of aircraft status without having to look down into the cockpit. Visionic devices are frequently used to provide pilotage imagery from multi-spectral sensors that provide flight and fire-control capability at night and in weather-related periods of low visibility.

For ground vehicles, the same advantages cited for aviation are present. In addition, tank and other vehicle drivers and commanders can perform the mission from a "buttoned up" position, minimizing exposure to enemy fire.

For the dismounted ground soldier, "they (visionic devices) will enhance the soldier's ability to engage and defeat enemy targets while minimizing friendly casualties," and provide better access to digitized battlefield data[1].

For these reasons and for more global benefits, such as decreased workload, visionic devices are proliferating in the modern battlespace and finding applications in all facets of modern warfare.

2.2 Test and Evaluation

The major goal of any product development is the successful performance of the device in the intended operational environment. Ideally, every engineering design would perform as designed. However, in reality, most designs at best need optimization; at worst, they need major changes. It is the primary purpose of a test and evaluation program to verify and validate performance against stated specifications and requirements. Such testing ensures planned capabilities are actually delivered and fosters user confidence in the product.

A comprehensive test and evaluation program must identify the critical operational parameters. Next, a battery of test methodologies must be selected in order to achieve measurements of values of the identified test parameters. Testing tends to be divided into three broad categories: laboratory (bench), simulation and operational (field).

Laboratory testing is the easiest to conduct, due to the controlled environment. Tests can be performed at both system and subsystem levels. However, laboratory testing does not capture performance under actual operating conditions. Laboratory testing is most appropriate and useful during early developmental stages when only components or subsystems are available for evaluation. Additionally, testing is being performed to validate an approach or design feature, with feedback to the design process being a major result of the testing. Laboratory tests should not be considered fully adequate to validate performance; however, neither should it be considered unnecessary, as it can play an important role in identifying major problems.

Simulation testing adds a level of sophistication. Such testing attempts to add an operational environment component to the testing and evaluation program but without the added logistics and cost of field testing. Simulation testing offers a more cost-effective way to test performance under a multitude of operational factors; e.g., temperature, altitude, velocity, g-loading, etc. Simulation testing can increase confidence in the validity of the performance of the device under evaluation. It increases the cost to the testing procedure, but is still cost effective as compared to full field testing. However, simulation testing can fail to measure performance under the full impact of the total operational environment.

Field testing is the approach that provides the most confidence in validating performance in the actual operational environment. Field testing is the most expensive category of testing and is most fraught with logistical problems. Cost and schedule often limit this important category of testing. However, such testing is the only true measure of performance.

An important issue in the test and evaluation process is whether or not to include humans in the testing approach (when human users are in the operational loop of the system or device under test). In general, when humans are integral to the use of the system/device, failure to include human physiology and human factors in the testing will result in a poor validation of true performance. Such issues as anthropometrics, fatigue, and workload must be included in testing to ensure a true measure of performance.

2.3 Unique Characteristics of Testing Visionic Devices

The function of a visionic device is to provide the user with imagery and symbology that allows enhanced operation for designated tasks. Visionic devices present several characteristics that make testing them unique when compared to traditional displays. It has been recognized that the development of visionic devices requires specialized methodologies to assess their performance.

Panel-mounted, directly viewed displays can usually be fully characterized by luminance, contrast, color, and resolution. Visionic devices require these measures of image quality, but also require a number of other parameters that are associated with the optical system that delivers the image to the eye. Examples of these added parameters include exit pupil definition, field of view (FOV), magnification, optical aberrations, etc. In addition, the man-machine interface between the device and the user's visual system introduces a number of other parameters requiring evaluation, e.g., interpupillary distance, optical alignment and disparity (in binocular/binocular devices), physical eye relief, etc.

Perhaps the most challenging characteristic of visionic devices is the exit pupil concept. An exit pupil is defined as a small volume in space along the optical axis where all of the image-forming rays meet. In order for the user to be able to see the full, unvignetted image, the user's eye (entrance pupil) must be fully within the system's exit pupil (Figure 4). To define a device's exit pupil, its position, shape and size must be measured.

Although all visionic systems requiring relay optics to deliver the image to the user's eye form exit pupils, not all devices are exit-pupil-forming systems. A non-pupil-forming virtual device uses a simple eyepiece to collimate or focus a real image source. Many current versions of image intensification devices are non-pupil-forming systems.

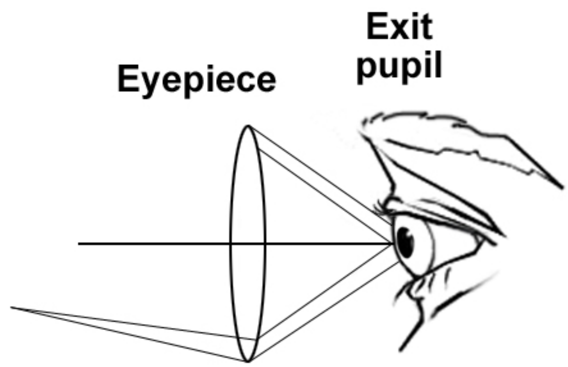

Figure 4. Schematic of an exit-pupil-forming visionic device.

2.4 Current Approaches to Testing and Evaluation of Visionic Devices

Currently, there is no universal standard for testing performance of visionic devices. Each test facility establishes its own test plan based on the visionic device design, individual bias in identifying important test parameters, and test equipment availability. Some test facilities have automated certain tests, and several commercial vendors have developed limited automated test systems.

Rash et al.[2] developed a comprehensive battery of tests and test methodologies based on experience with the AH-64 monocular IHADSS visionic device. While an exhaustive list of test parameters and procedures were presented, no guidance was provided in identifying critical test parameters for any given device design. A NATO Standard (STANAG) 7041-ED1, "Integrated Helmet Display System for Rotary and Fixed Wing Aircraft," [3] based on this report, is in the ratification stage with member nations.

Marasco and Task [4] presented a large array of tests applicable to image intensification-based visionic devices. In developing tests for the Panoramic Night Vision Goggle (PNVG), the authors considered the current testing methodologies to be insufficient to fully characterize the novel PNVG optical design. New tests were developed, concentrating primarily on four test parameters: field of view, visual acuity, eyepiece diopter setting, and image discontinuity.

Standardizing field test approaches is even more difficult. One example is a flight test battery developed by Haworth, Blanken & Szoboszlay [5] for evaluating Night Vision Goggle (NVG) performance in flight using maneuvers from Aeronautical Standard-33 (ADS-33)[6].

When a facility is involved in continuous or high volume testing, it has been found to be advantageous to automate certain test set-ups and procedures. Hsieh, Harding, Rash, Beasley & Martin[7] built a prototype tester for evaluating image quality for the AH-64 IHADSS. Fellowes and Draper [8] developed a near-to-eye display test station utilizing "kinematically interchangeable sensor heads" to allow multiple spectrum testing on devices without having to disassemble the eyepiece. Martin, Beasley, Verona & Rash [9] developed a semi-automated test system specifically for image intensification devices that measured FOV, magnification, and distortion.

A number of automated measurement systems have been commercially developed. One of these is the Helmet-Mounted Display Universal Optical Test System (Figure 5) manufactured by Sira, (Chislehurst, Kent, United Kingdom). The test system is centered about an artificial eye. The artificial eye is integral to an image analyzer and has an entrance pupil that can be positioned where the user's pupil would normally be located. A charge-coupled device (CCD) camera is used to simulate a retina. The image analyzer can be operated inside a helmet and moved around to simulate all the pilot's possible fields of view. The analyzer's optical system forms a real image of the virtual image of the test pattern, generated by the device under test, in the focal plane of the CCD camera. More than 17 optical parameters can be tested with this system including diopter setting, FOV, modulation transfer function, distortion, contrast, luminance and luminance uniformity.

For image intensification devices, Hoffman Engineering (Stamford, CT) markets several test sets. One example is the ANV-126 Test Set (Figure 6), which is a field-portable system. It contains a set of test functions that measure gain, resolution, distortion, and spot defects. These tests can be performed in quick succession under a wide range of simulated night-time light levels.

While automated systems can save time and have greater repeatability, these systems measure only a small subset of what are considered critical operating parameters of visionic devices.

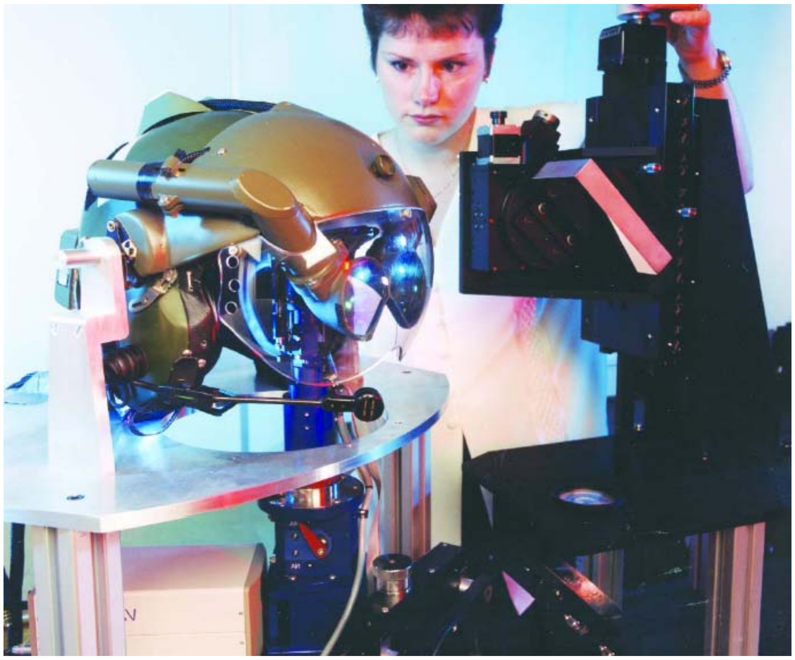

Figure 5. Helmet-Mounted Display Universal Optical Test System (Sira).

Figure 6. The ANV-126 Test Set (Hoffman Engineering).

Currently, there is a wide disparity between test plans developed and implemented across testing facilities. While there may be a general consensus as to which test parameters should be measured, there is a no agreement on test equipment and methodologies.

3. WORKING GROUP GOAL

A NATO HFM Panel was convened to address the human factors areas that affect the warfighter's ability to acquire, process and make effective decisions using task-critical information. Under this panel, a Research and Technology Group (RTG) was formed. This working group has been tasked with creating a document that will provide guidelines for standardizing the selection and implementation of various test and evaluation methodologies for measuring the performance of prototype and production visionic devices. The working group is more formally designated as HFM-091/RTG-027, "Common methodological basis for evaluation and testing of visionic devices."

The working group is comprised of 13 participants representing six nations (Canada, France, Germany, Netherlands, United Kingdom and United States). Participants were selected based on their subject-matter expertise in the areas of sensors, optics, HMDs, human factors, and test and evaluation. To facilitate the development of the document, the working group was organized into two subgroups: laboratory testing and field testing. The laboratory testing subgroup was further organized into optical, sensory and cognitive areas. This paper reports only on the development of common methodologies for optical testing.

The guidance to be provided in the RTO report is based on the expertise of the working group participants and an exhaustive review of HMD literature. The contents of the report should be considered as guidelines only.

4. UNIFIED TESTING APPROACH

The approach taken for laboratory optical testing, and presented herein, is based on optical design (see-through vs. non-see-through and monocular vs. biocular/binocular) and display type. The approach first requires identifying the device under test as either a non-see-through (sometimes designated as Type 1) or see-through (sometimes designated as Type 2). In a *non-see-through* optical design, the user views only sensor imagery and does not have a direct, unaided view of the external scene. Examples of non-see-through include most image intensification-based systems; e.g., F4949 NVGs and ANVIS. The concept of *see-through* implies that the user views sensor imagery overlaid upon the external scene. As depicted in Figure 7, the combined imagery is accomplished using a beamsplitter (combiner). Examples of see-through systems include IHADSS, Cat's Eyes NVGs and TopOwl.

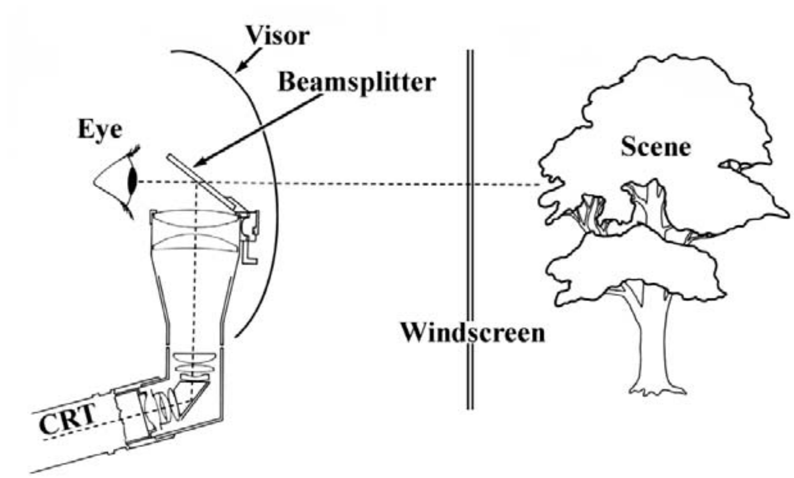

Figure 7. Schematic diagram showing the use of a beamsplitter in combining sensor and external scene imagery.

The second step in the approach requires identification of display type. The choice is between image intensification systems (where the sensor and display are integrated into a single component) and stand alone displays; e.g., cathode-ray-tubes, liquid crystal displays, etc.

It is then necessary to revisit the optical design and determine if the device under test uses a monocular or biocular/binocular presentation mode. Biocular/binocular systems require additional testing for alignment disparities between imagery presented to the two eyes. Once these three determinations are made for the device under test, tables can be consulted for a list of recommended test parameters and the relative importance of each parameter. Tables 1 and 2 present the developed optical test parameter taxonomy.

All recommended tests are applicable to the operational combinations of image source, optics, protective visors, and ancillary devices. Visors can be classified as clear, tinted (sun protective), or special class (directed energy protective and other special purpose visors).

The recommended test methodologies can apply to both the total system and display component levels. A specific test may be performed for multiple system configurations. Where applicable, all operational combinations of the display optics, visor(s), and ancillary devices shall be tested, as required.

Recommended test criteria are adapted from STANAG 7041-ED2 Integrated Helmet-Mounted Display System[3], Military specification MIL-V-43511C, "Visors, flyer's, helmet, polycarbonate,"[10] and Rash et al [2]. Other criteria cited in specific requirements documents may be substituted.

In the tables, the first row designates the optical design approach, the second row designates display type, and the third row designates between monocular and biocular/binocular presentation modes. For a given characterization of a visionic device based on these three factors, a list of recommended test parameters is presented.

Each test parameter has an associated test priority rank. A rank level of high, medium or low is assigned to each test according to its importance in verifying the performance of the visionic device under test. A ranking of *high* implies that the test measurement is considered critical and should be required. A ranking of *medium* implies that the test measurement is considered important and is recommended. A ranking of *low* implies that the test measurement is considered useful but is optional.

Once a decision has been made as to which tests will be performed, the RTO report can be consulted for suggested testing apparatus and methodology for each test. The report provides a recommended test objective, criteria, apparatus, methodology and analytical method for each test parameter. The following example describes the test method for the *Luminance Disparity* parameter:

Luminance Disparity (Medium)

Objective: To determine the difference (or mismatch) in luminance between the right and left visionic devices channels (if system is biocular or binocular) at low, medium, and high luminance settings. If the visionic device is biocular, only one 1uminance setting is required. Note: This test is not required if the brightness of each channel can be independently adjusted by the user.

Criteria: Central field luminance values for left and right channels shall differ by no more than 30 percent (0.15 log units) at low, medium, and high mean luminance values of presented imagery. Suggested display values for measurements are 0.1, 1.0, and 10 foot-Lamberts. For an integrated helmet mounted image intensification device, the upper luminance value of the display shall be at the threshold of the automatic gain control. Where required, additional or alternate criteria from specification documents shall be used for this test.

Apparatus: A photometer having an accuracy of ±2 percent, a full scale sensitivity of 1.0 foot-Lambert or less, and photopic and scotopic filters and an electronically generated negative contrast cross-hair using raster imagery are required.

Methodology: Measurements are made in a dark room with the photometer focused on the exit pupil of the visionic device along the optical axis. The display contrast in each channel is maximized. The visionic devices display brightness is adjusted to the medium luminance level (1.0 foot-Lambert) in one channel. The luminance of the alternate channel is measured and recorded. This procedure is repeated for the low (0.1 foot-Lambert,) and high (10 foot-Lamberts) luminance conditions.

Analytical Method: The luminance differences between the right and left channels are calculated and compared with system specifications for the three luminance conditions using the following equation:

$$\% \text{ Disparity} = 100*[1 - (L_L / L_H)]$$

Where:

L_L = luminance of the channel with the lowest luminance value

L_H = luminance of the channel with the highest luminance value.

In this example, the word *Medium* located after the test parameter name (Luminance Disparity) indicates the recommended test rank priority. The *Objective* section defines the purpose of the test and the *Criteria* section provides nominal test values. The *Apparatus* section provides guidance as to the selection of test equipment but may be modified to meet laboratory capabilities. Last, the *Analytical Method* section provides the evaluator with the appropriate steps for converting the raw measurement data into meaningful values.

Table 1. Visionic optical test parameter taxonomy.

Non-See-Through (Type 1)							
Image Intensifier Based				CRTs, LCDs, LEDs, etc.			
Monocular		Biocular/Binocular		Monocular		Biocular/Binocular	
Test	Priority	Test	Priority	Test	Priority	Test	Priority
Chromatic Aberration	Low	Binocular Overlap	Medium	Chromatic Aberration	Low	Binocular Overlap	Medium
Exit Pupil Size and Shape	Medium	Chromatic Aberration	Low	Contrast Ratio	High	Chromatic Aberration	Low
Extraneous Reflections	Medium	Exit Pupil Size and Shape	Medium	Distortion	High	Contrast Ratio	High
Eyepiece Focus Range	Medium	Extraneous Reflections	Medium	Exit Pupil Size and Shape	Medium	Distortion	High
Field-of-View	High	Eyepiece Focus Range	Medium	Extraneous Reflections	Medium	Exit Pupil Size and Shape	Medium
Halo (I^2)	High	Field-of-View	High	Eyepiece Focus Range	Medium	Extraneous Reflections	Medium
I^2 Tube Defects	High	Halo (I^2)	High	Field-of-View	High	Eyepiece Focus Range	Medium
Image Rotation	Medium	I^2 Tube Defects	High	Gray Scale	High	Field-of-View	High
Luminance Gain (I^2)	High	Image Rotation	Medium	Image Rotation	Medium	Gray Scale	High
Luminance Uniformity	Medium	Image Rotation Disparity	Medium	Luminance Range	High	Image Rotation	Medium
Magnification	High	Image Size Disparity	Medium	Luminance Uniformity	Medium	Image Rotation Disparity	Medium
Maximum Luminance (I^2)	Medium	Interpupillary Distance	Medium	Magnification	High	Image Size Disparity	Medium
Modulation Contrast	High	Luminance Disparity	Medium	Modulation Transfer		Interpupillary Distance	Medium
Objective Lens Focus Range	High	Luminance Gain (I^2)	High	Function	High	Luminance Disparity	Medium
Operationally Significant		Luminance Uniformity	Medium	Physical Eye Relief	High	Luminance Range	High
Source Transmittance	High	Magnification	High	Resolution	High	Luminance Uniformity	Medium
Physical Eye Relief	High	Magnification Disparity	High	Spherical/Astigmatic		Magnification	High
Resolution	High	Maximum Luminance (I^2)	Medium	Aberrations	Low	Magnification Disparity	High
S-Distortion (I^2)	Low	Modulation Contrast	High			Modulation Transfer	
		Objective Lens Focus Range	High			Function	High
		Operationally Significant				Optical Axis Alignment	
		Source Transmittance	High			Disparity	High
		Optical Axis Alignment				Physical Eye Relief	High
		Disparity	High			Prismatic Deviation	
		Physical Eye Relief	High			Disparity	High
		Prismatic Deviation Disparity	High			Resolution	High
		Resolution	High			Spherical/Astigmatic	
		S-Distortion (I^2)	Low			Aberrations	Low

Table 2. Visionic optical test parameter taxonomy.

See-Through (Type 2)							
Image Intensifier Based				CRTs, LCDs, LEDs, etc.			
Monocular		Biocular/Binocular		Monocular		Biocular/Binocular	
Test	Priority	Test	Priority	Test	Priority	Test	Priority
Chromatic Aberration	Low	Binocular Overlap	Medium	Chromatic Aberration	Low	Binocular Overlap	Medium
Exit Pupil Size and Shape	Medium	Chromatic Aberration	Low	Contrast Ratio	High	Chromatic Aberration	Low
Extraneous Reflections	Medium	Exit Pupil Size and Shape	Medium	Distortion	High	Contrast Ratio	High
Eyepiece Focus Range	Medium	Extraneous Reflections	Medium	Exit Pupil Size and Shape	Medium	Distortion	High
Field-of-View	High	Eyepiece Focus Range	Medium	Extraneous Reflections	Medium	Exit Pupil Size and Shape	Medium
Halo (I^2)	High	Field-of-View	High	Eyepiece Focus Range	Medium	Extraneous Reflections	Medium
I^2 Tube Defects	High	Halo (I^2)	High	Field-of-View	High	Eyepiece Focus Range	Medium
Image Rotation	Medium	I^2 Tube Defects	High	Gray Scale	High	Field-of-View	High
Luminance Gain (I^2)	Medium	Image Rotation	Medium	Image Rotation	Medium	Gray Scale	High
Luminance Uniformity	Medium	Image Rotation Disparity	Medium	Luminance Range	High	Image Rotation	Medium
Magnification	High	Image Size Disparity	Medium	Luminance Uniformity	Medium	Image Rotation Disparity	Medium
Maximum Luminance (I^2)	Medium	Interpupillary Distance	Medium	Magnification	High	Image Size Disparity	Medium
Modulation Contrast	High	Luminance Disparity	Medium	Modulation Transfer Function	High	Interpupillary Distance	Medium
Neutrality	Medium	Luminance Gain (I^2)	High	Neutrality	Medium	Luminance Disparity	Medium
Objective Lens Focus Range	High	Luminance Uniformity	Medium	Operationally Significant Source Transmittance	High	Luminance Range	High
Operationally Significant Source Transmittance	High	Magnification	High	Physical Eye Relief	High	Luminance Uniformity	Medium
Physical Eye Relief	High	Magnification Disparity	High	Refractive Power	High	Magnification	High
Refractive Power	High	Maximum Luminance (I^2)	Medium	Resolution	High	Magnification Disparity	High
Resolution	High	Modulation Contrast	High	See-through Luminance Transmittance	High	Modulation Transfer Function	High
S-Distortion (I^2)	Low	Neutrality	Medium	See-through Spectral Transmittance	Low	Neutrality	Medium
See-through Luminance Transmittance	High	Objective Lens Focus Range	High	Spherical/Astigmatic Aberrations	Low	Operationally Significant Source Transmittance	High
See-through Spectral Transmittance	Low	Operationally Significant Source Transmittance	High			Optical Axis Alignment Disparity	High
		Optical Axis Alignment Disparity	High			Physical Eye Relief	High
		Physical Eye Relief	High			Prismatic Deviation Disparity	High
		Prismatic Deviation Disparity	High			Refractive Power	High
		Refractive Power	High			Resolution	High
		Resolution	High			See-through Luminance Transmittance	High
		S-Distortion (I^2)	Low			See-through Spectral Transmittance	Medium
		See-through Luminance Transmittance	High			Spherical/Astigmatic Aberrations	Low
		See-through Spectral Transmittance	Low				

5. SUMMARY

The increased usage of visionic devices necessitates the development of a unified approach to testing and evaluation of such devices. The HFM/RTG-027 working group was established to achieve this goal. This presentation describes a taxonomy that can be used to classify a given visionic device (based on optical design and display type) and to recommend specific test parameters that should be measured to ensure planned operational performance is delivered in the final product.

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7. DISCLAIMER

The views, opinions and/or findings contained in this report are those of the authors and should not be construed as an official Department of the Army position, policy, or decision unless designated by other documentation.

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