INTRODUCTION

Night vision goggles (NVGs) were first developed and introduced by the US Army for use by ground forces. They were later adapted for use in rotary- and fixed-wing aircraft. The Human Engineering Division of the Armstrong Aerospace Medical Research Laboratory (later becoming the Crew Systems Interface Division of the Air Force Research Laboratory or AFRL/HEC) at Wright-Patterson AFB, Ohio first became involved in Air Force use of NVGs in the late 1970s. Using NVGs in aircraft presented a unique and challenging set of cockpit and human-system integration issues. These issues were the focus of much of AFRL/HEC's involvement in the research, development and use of NVGs. Some of these integration issues include: visual acuity, resolution, peripheral vision, weight, transparency effects (materials, coatings, geometry), cockpit lighting compatibility, laser eye protection, G effects, egress, NVG characterization (signal-to-noise ratio, gain, modulation transfer function, field of view, dark spots, distortion, magnification, image rotation), optical design and aircrew acceptance criteria. This document provides a summary of the night vision research and development efforts of AFRL/HEC over the past twenty-plus years. It includes the complete text of selected in-house publications addressing visual acuity, lighting and display compatibility, panoramic NVGs, the measurement of NVGs and their related components and human factors interface issues. Also, included is a listing of this Division's night vision related patents and a bibliography of other AFRL/HEC night vision articles.

I. SELECTED NIGHT VISION RELATED PUBLICATIONS

1. VISUAL ACUITY AND NIGHT VISION GOGGLES

One of the most frequently referenced parameters relating to the capability or quality of night vision goggles is visual acuity. This parameter is often mistakenly referred to as the *visual acuity of NVGs*. Since visual acuity is an attribute of human vision, this statement is incorrect. However, the intent of this statement is to convey a sense of the performance level that the NVGs can attain. When one is referring to an optical instrument or display, such as an NVG, the appropriate term to use is *resolution*. Resolution is the level of detail that an optical or display device can sense or resolve independent of whether or not the human eye can actually see the level of detail. Since both metrics can have the same units (such as cycles/mrad), it is easy to understand why these two different terms are often used interchangeably.

Several parameters can affect human visual acuity independently of the NVGs, such as luminance (how much light is getting into the eyes) and contrast (what is the difference or ratio between the bright and dark areas of the image that is used to test visual acuity). In general, as light level and contrast are reduced, visual acuity is degraded. Therefore, visual acuity obtained when viewing through NVGs tends to be worse when the light and contrast are reduced.

This section contains select publications that deal with the issue of assessing human visual acuity capability, while using NVGs. The first article, Pinkus & Task (1998), discusses the basics of measuring human visual acuity through night vision goggles. The second article, Pinkus, Task, Dixon & Goodyear (2000), investigates the variability associated with measuring visual acuity through NVGs. Task (2001) describes the results of an interagency test to determine the repeatability and reproducibility of NVG visual acuity. Each participating organization used their own NVG visual acuity test procedures on the same two pair of NVGs. Pinkus & Task (1997) demonstrates that visual acuity is reduced when viewing through aircraft transparencies that have lower night vision imaging system (NVIS) transmission coefficients (less available near infrared light). Different canopy coatings can have different transmission effects. Task, Riegler & Goodyear (1999) shows that the reduction in visual acuity due to light loss can be caused by transmission effects either at the eyepiece of the NVGs or at the objective lens. For example, aircraft transparencies cause a reduction of light entering the objective lens, while aircrew laser eye protection or glasses cause a reduction of light at the eyepiece side of the NVG. Riegler, Whiteley, Task & Schueren (1991) explores the effects of light level, contrast and the inherent signal/noise ratio of the image intensifier tube on visual acuity. Gleason & Riegler (2001) describes the impact of the diopter setting of the NVG eyepiece, on visual acuity for both short term and long term wear of the NVGs. The last article, Donohue-Perry, Task & Davis (1994), shows the effect of field of view (FOV) on visual acuity through NVGs. For a given image intensifier tube, the same number of pixels (picture elements or resolution elements) must be spread over a larger angular area to get a larger FOV. This spread increases the visual angle per resolution element, thereby reducing the device's resolution and the visual acuity that can be obtained.

These articles are reprinted to provide the reader with a reference and background to better understand NVG-aided visual acuity.

Pinkus, A. R., & Task, H. L. (1998). **Measuring observers' visual acuity through night vision goggles.** *Proceedings of the 36th Annual Symposium SAFE Association* (pp. 1-11).

Pinkus, A. R., Task, H. L., Dixon, S. A., & Goodyear, C. D. (2000). **Reproducibility limits of night vision goggle visual acuity measurements.** *SAFE Journal, 30(1),* 131-139.

Task, H. L. (2001). **Night vision goggle visual acuity assessment: results of an interagency test.** *Proceedings of SPIE – International Society for Optical Engineering Helmet- and Head-Mounted Displays VI, USA, 4361,* 130-137.

Pinkus, A. R., & Task, H. L. (1997). **The effects of aircraft transparencies on night vision goggle-mediated visual acuity.** *Proceedings of the 35th Annual Symposium SAFE Association,* (pp. 93-104).

Task, H. L., Riegler, J. T., & Goodyear, C. D. (1999). **Effects of laser eye protection and aircraft windscreens on visual acuity through night vision goggles.** *Proceedings of the 37th Annual Symposium SAFE Association,* http://www.safeassociation.com

Riegler, J. T., Whiteley, J. D., Task, H. L., & Schueren, J. (1991). ***The effect of signal-to-noise ratio on visual acuity through night vision goggles.*** (Report No. AL-TR-1991-0011). Wright-Patterson AFB, OH: Armstrong Laboratory. (DTIC No. A260579)

Gleason, G. A., & Riegler, J. T. (2001). ***The effect of eyepiece focus on visual acuity through ANVIS night vision goggles during short- and long-term wear.*** (Report No. AFRL-HE-WP-TR-2001-0033). Wright-Patterson AFB, OH: Air Force Research Laboratory.

Donohue-Perry, M. M., Task, H. L., & Davis, S. A. (1994). ***Visual acuity vs. field-of-view and light level for night vision goggles (NVG).*** (Report No. AL/CF-TR-1994-0076). Wright-Patterson AFB, OH: Armstrong Laboratory. (DTIC No. A284750)