2. NIGHT VISION IMAGING SYSTEM (NVIS) COMPATIBILITY: LIGHTING AND DISPLAYS

The compatibility or incompatibility of aircraft cockpit lighting and displays with NVGs is a major issue in aviation. In general, the aircraft interior lighting and displays are considered compatible if they do not interfere with the exterior scene-viewing capability of the NVGs. Since observers look under the goggles to directly see the cockpit instruments and displays (except for viewing the head-up display), a compatible cockpit must also provide sufficient light of appropriate color content equivalent to that of a non-compatible cockpit. A related issue is that the NVG-compatible lighting and displays must also be useable under daylight conditions. When NVGs were first used in aircraft cockpits, they were called second-generation devices because they used second-generation image intensifier tubes. These tubes were sensitive to light across the entire visual spectrum (400 nm blue through 700 nm red) as well as through the near-infrared (NIR; 700 nm through 950 nm). Since cockpit instrumentation emits large amounts of NIR, it is extremely difficult to make it fully compatible (as defined above) with NVGs. Techniques to improve NVG compatibility by using complementary color filters also resulted in lowered second-generation NVG performance (Task & Griffin, 1982a; 1982b).

Compliant lighting refers to cockpit lighting systems that meet the specific luminance and night vision imaging system (NVIS) radiance requirements of Mil-L-85762A (26 August 1988, Military Specification, Lighting, Aircraft, Night Vision Imaging System (NVIS) Compatible.) and Mil-Std-3009 (2 February 2001, Department of Defense Interface Standard for Lighting, Aircraft, Night Vision Imaging System (NVIS) Compatible). It is possible for an aircraft cockpit lighting and display system to be NVG compatible, as previously defined, but not be NVG compliant, as per Mil-L-85762A. Recent, as yet unpublished, studies show that the reverse may also be true if the lighting or displays produce direct reflections in the aircraft windscreen that the NVGs must view through.

Another issue associated with NVG-lighting compatibility involves external lighting (navigation lights, anti-collision strobes, position lights, etc.). None of the articles in the present section address this issue, but it is normally highly desirable to make sure the external aircraft lighting can be used in conjunction with the NVGs without causing degradation in NVG performance.

The first article, Blouin (1997), provides basic information about human vision and dark adaptation. This is an important issue because visual acuity through NVGs tends to be improved by increasing the output luminance of the NVGs. This increase changes the individual's light adaptation state, making it necessary for the cockpit lighting to be correspondingly higher, so that crewmembers can properly see their instruments and displays. Task & Griffin (1982a; 1982b) describe various techniques developed to make helicopter cockpit lighting NVG compatible. Slusher (1985) provides an excellent reference for the determination of what luminance level should be attained in the aircraft cockpit for aircrew use. Pinkus (1988) describes a broad view of techniques used to make a cockpit NVG compatible. Donohue-Perry (1984) demonstrates that electroluminescent lighting obeys the laws of photometry and can be used for NVG

compatible lighting. Craig, Bartell, Hettinger & Riegler (1993) describes NVG compatible lighting for fixed-wing aircraft. Marasco, Bowyer & Boulter (2001) and Marasco (2001) examine the issue of "super" luminance levels for cockpit displays in order to achieve higher aircrew member visual acuity capability with respect to the display and the displayed information. The last article, Task (1998), describes the pros and cons of using chemical light sticks as an interim method of achieving NVG compatible lighting.

These articles are reprinted to provide the reader with a reference and background to better understand NVIS compatibility of lighting and displays.

Blouin, G. K. (1982). ***Dark adaptation of rated Air Force officers using electroluminescent versus incandescent light sources.*** (Report No. AFAMRL-TR-82-2). Wright-Patterson AFB, OH: Air Force Aerospace Medical Research Laboratory.

Task, H. L., & Griffin, L. L. (1982a). **Electroluminescent lighting and other techniques for improving night vision goggle compatibility with cockpit displays.** *AGARD Conference Proceedings, No. 329.* Blackpool, UK. (NTIS No. AGARD-CP-329*)*

Task, H. L., & Griffin, L. L. (1982b). **PAVE LOW III: Interior lighting reconfiguration for night lighting and night vision goggle compatibility.** *Aviation, Space and Environmental Medicine, 53,* 1162-1165.

Slusher, W. M. (1985). ***Instrument lighting levels and AN/AVS-6 usage.*** (Report No. AAMRL-TR-85-055). Wright-Patterson AFB, OH: Armstrong Aerospace Medical Research Laboratory. (DTIC No. A161538)

Pinkus, A. R. (1988). **Night lighting and night vision goggle compatibility.** *AGARD Lecture Series 156: Visual Effects in the High Performance Aircraft Cockpit* (pp. 7-1 through 7-16). Neuilly Sur Seine, France: NATO Advisory Group for Aerospace Research & Development. (NTIS No. AGARD-LS-156)

Donohue-Perry, M. M. (1984). ***Brightness comparison of electroluminescent versus incandescent lighting: a photometric validation.*** (Report No. AFAMRL-TR-84-036). Wright-Patterson AFB, OH: Air Force Aerospace Medical Research Laboratory.

Craig, J. L., Bartell, R. J., Hettinger, L. J., & Riegler, J. T. (1993). ***Assessment of interior modifications in C-130 and C-141 aircraft for night vision goggle operations.*** (Report No. AL/CF-TR-1993-0095). Wright-Patterson AFB, OH: Armstrong Laboratory.

Marasco, P. L., Bowyer, R. L., & Boulter, A. E. (2001). ***Night vision imaging system (NVIS) compatibility and visibility of the F-16 common configuration implementation program (CCIP) common color multi-function display (CCMFD).***

(Report No. AFRL-HE-WP-TR-2002-0006). Wright-Patterson, AFB, OH: Air Force Research Laboratory.

Marasco, P. L. (2001). **The visibility of night vision imaging system compatible displays.** *Proceedings of the 39th Annual Symposium SAFE Association,* http://www.safeassociation.com

Task, H. L. (1998). **Chemical lightsticks as a night vision goggle compatible lighting technique for aircraft cockpits: characteristics, pros and cons.** *Proceedings of the 36th Annual Symposium, SAFE Association* (pp. 34-38).