Photo by Staff Sargent Joshua Strang USAF

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Brushing Back *the* Dark

A Look at the Latest in Night Vision Technology

The ability to adapt is a wonderful thing. In the animal kingdom, adaptation is typically accomplished by biological means. Sometimes this means an animal develops bigger teeth or stronger muscles. Sometimes it means lighter bones and co-opted structures like feathers for flight. Humans, however, have largely adapted by developing technologies. We use technology to bridge the gap between what we would like to achieve (i.e., flight), and what our bodies will allow.

One area in which humans have always been the weaker species in is vision and specifically *night* vision. While many other animals developed better night vision or evolved their other senses to compensate, for the last 100,000 years or so, our only technological recourse was to carry light (e.g., fire) with us. This all changed in World War II. Since then we've been rapidly closing the gap between us and other animals.

Lighting the Way

There are two basic kinds of technology that comprise our night vision arsenal: light amplification and alternate wavelength. These two technologies have very different operating principles and implementations. With these differences come varying advantages and disadvantages.

The most prominent example of light amplification technology is the night vision goggle system (NVG). They work by doing exactly what the name says: they amplify the ambient light by as much as 50,000 times, according to some reports. That's quite an improvement from the Vietnam era Generation I systems that required at least some moonlight to function, and even early Generation 0 systems that required a separate infrared lighting source. The current Generation III requires virtually no light to function and can make an apparently pitch black environment light up like a sunny day.

Alternate wavelength technology works by using sensors that can "see" in other wavelengths of energy. The most common example would be infrared (IR). IR allows you to see heat energy, or more specifically, *differences* in heat energy. IR technology tends to be aircraft-mounted due to the size and power demands of the sensor. Earlier sensors had to be cooled to very low temperatures in order to work. This meant larger, more complicated installations on the aircraft and also tended to require wait times to cool the sensor to operating temperature. Not only do these IR sensors help shed light on the darkness, they also can improve visibility through some common visual obstructions such as fog, snow, or rain.

Another example of alternate wavelength technology is millimeter wavelength radar. Millimeter wave radar is one of the technologies specifically allowed by rule, but it is largely out of reach for the GA world. For the purposes of this article, therefore, our use of the term "IR technology" is intended to represent the group of alternate wavelength technologies.

At Home in the Dark

Night vision imaging systems (NVIS) falls into the category of light amplification technology. The advantages with this technology are significant, but it is not without its limitations. One issue is depth perception as some designs only use single tubes in order to save on costs. This practice essentially turns the user into a bit of a Cyclops, thereby eliminating depth perception completely. Another issue is dramatically reduced peripheral vision. Most people are accustomed to about 190° of peripheral vision, but many NVGs offer only around 40°. The Department of Defense is working with advanced NVG designs that feature four tubes, instead of the more conventional one or two, to improve peripheral vision. Still, that change only boosts peripheral vision to a reported 95°. Lastly, there are concerns that the extra weight of the systems — which are head mounted — can cause increased fatigue and eye strain. NVGs also require significant modifications to be made to the aircraft, like the addition of filters to lights and switches to prevent the illumination from upsetting the NVGs.

For these reasons, the FAA places restrictions on the use of NVGs by pilots. In addition, there are also hardware certification requirements. Many of the prerequisite requirements for NVG use are found in 14 CFR part 61, specifically 61.1 (b)(12) and (13), 61.31(k), 61.51(k),61.57(f) and (g), and 61.195(k). There are also instrument and equipment requirements listed in part 91.205(h). Part 61.31(k) is critical

Photo Courtesy of Rockwell Collins

A HUD display of information from a Rockwell Collins EVS-3000 Enhanced Vision system.

as it states that you cannot use NVGs without proper training or experience. It further states the user must have received and logged both ground and flight training unless you meet very specific requirements. Additionally 61.195(k) requires that the instructor be specifically approved by the FAA. So to make a long story short, using NVGs isn't as simple as just putting a clip on your helmet.

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Heat Vision

While IR systems can be powerful tools to improve safety at night and during the day in periods of reduced visibility, they aren't a cure-all. Many IR systems can improve visibility through things like fog, rain, and snow, but they can't see through clouds. Also, IR sensors can't detect newer lighting systems such as LEDs since they don't emit heat. As mentioned above, the systems are generally required to be permanently installed in the aircraft. They include a pod or protuberance to house the sensor, in addition to a display in the cockpit. Even with the technological advances that have paved the way for "uncooled" sensors in newer products, they can be very expensive and require installation work. This makes the installation work to accompany NVGs seem very minimal.

EFVS vs. EVS

One issue with IR systems is that there is a regulatory distinction between Enhanced Flight Vision Systems (EFVS) and Enhanced Vision Systems (EVS). This may seem a bit redundant but, as with

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most complicated systems, the devil is in the details. Both systems provide the pilot with information — mainly IR information at the moment — in an effort to improve his or her situation awareness. But EFVS equipment offers the pilot the chance to go 100 feet below decision altitude (DA) or minimum descent altitude (MDA) to 100 feet above the touchdown zone elevation (TDZE) based on information from an approved EFVS.

An EVS doesn't offer the same benefit. In fact EVS equipment does not allow any change to DA/MDA protocol. EVS does offer similar benefits in terms of situation awareness and in many cases very similar hardware. So what's the difference? While EFVS is required to meet specific requirements that an EVS might not meet, the main difference is that an EFVS is required to display its information on a head up display (HUD). While there are other technical requirements to meet EFVS status, a major stumbling block can be the HUD. Most EVSs use either a primary or multi-function flight display (PFD or MFD) to display sensor information. Sometimes this information is even overlaid on to the other PFD information making it very close to what an EFVS provides through its HUD.

This does not mean that EVSs won't have a greater standing in the future. In fact, some avionics companies have done research and development on systems that would overlay sensor data and synthetic vision system (SVS) information on a PFD. Initial testing has looked promising showing results that are consistent with EFVS. There is still significant work to be done before such a system could be approved, and an approval could open the door for more benefits for the more accessible EVS systems.

U.S. Air Force photo

Many night vision systems are helmet mounted which can add strain and fatigue to operations.

Our ability to adapt technologically has enabled us to do what we couldn't 100 years ago — see clearly or, for that matter, fly in the dark. But like most of our tools, these advances aren't without limitations. To mitigate risks associated with these limitations, the FAA has established regulations and guidance for users of these technologies. Only with a proper understanding of the technology and its constraints, can we truly own the night.

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After extinguishing the fire, douse the device with water or other non-alcoholic liquids to cool the device and prevent additional battery cells from igniting. Do not cover the device or use ice in an attempt to cool it, because these actions will insulate the device and increase the possibility that additional battery cells will ignite.

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