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On the cover: Military platforms are being equipped with shortwave infrared (SWIR) cameras based on indium gallium arsenide (InGaAs) imaging technology because it provides exceptional clarity to positively identify targets during daytime and nighttime and through dust, fog, mist, haze and smoke. For more information, see the application note on page 64.

(Images courtesy of Sensors Unlimited and The Boeing Company)

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Applications

Shortwave Infrared - The Latest Weapon in the War on Terror

By David G. Dawes

Keeping one step ahead of our adversaries is top priority for security forces with terrorist threats growing daily around the world. Intelligence, surveillance and reconnaissance are the core situational awareness tools for the global war on

Figure 1. Sensors Unlimited SU640KTSX InGaAs NIR/SWIR Camera (OEM version). The 640 x 512 pixel format camera features a 25 µm pixel pitch focal-plane array responsive from 0.7 - 1.7 microns and gathers full-sized images at 30 fps.

terrorism (GWOT). Just as night vision equipment has denied terrorists the cover of darkness for more than a couple of decades, emerging shortwave infrared imaging technology is now removing weather and environmental limitations from the ISR equation.

Shortwave infrared exploits the third and final atmospheric window in the infrared spectrum. SWIR, long the domain of the high altitude U-2 spy plane with its cryogenically-cooled focal plane array (FPA) technology, has powerful capabilities not widely known outside the intelligence community until recently. SWIR makes long slant range imaging possible under practically any conditions. A revolution in imaging has recently been developed via breakthrough, indium gallium arsenide (InGaAs) FPA technology, resulting in lighter weight, more compact cameras. These new uncooled InGaAs imagers offer the advantages of the shortwave infrared spectrum to see beyond the visible, and because of their ultra-compact design, they can be implemented on the smallest UAVs (unmanned aerial vehicles) and man-portable platforms.

Powerful Capability in a Small Package

Figure 1 shows the SU640KTSX InGaAs SWIR imager from Sensors Unlimited, Inc. (Princeton, NJ) in its OEM configuration. This compact imaging sensor weighs less than 90g and is capable of full motion video at a 640 x 512 pixel resolution from daylight to starlight while operating uncooled at room temperature. The SWIR camera features extremely high-quantum-efficiency InGaAs technology with excellent spectral response from 0.9 to 1.7 microns and extending down to 0.7 microns in the NIR/SWIR version, a broad spectral range encompassing all the key battlefield laser wavelengths. Requiring as little as 2.5 watts of electrical power, the SU640KTSX is attracting a lot of interest for small UAV and man-portable applications.

Until recently, only visible, and to some extent long-wave infrared (LWIR, 8 to 12 microns), imaging payloads had been flown on the smaller UAVs. The visible imagers could not be used at night, while uncooled LWIR microbolometers had limited sensitivity or resolution at long range and were especially disadvantaged during dawn and dusk thermal cross-overs. SWIR brings a lot to

Figure 2. Comparative SWIR (left) and visible (right) images of haze taken on the approach to Death Valley, CA

Figure 3. Comparative SWIR (left) and visible (right) images taken in the dusty Pine Barrens of southern New Jersey

the table, not only bridging the capability gaps of the other technologies, but also offering the most comprehensive all weather, all environmental, and all around-the-clock operability in a single uncooled sensor package.

All Weather, All Environment Capability

The ability to see clearly over long distances seems to be diminishing, globally, whether due to rising pollution levels of growing urban development or more natural causes. Haze, once only an urban challenge, now even compromises the view in remote locations like Death Valley, California. In probably one of the best examples of imaging in the SWIR wavelength, Figure 2 shows how scene detail, lost to the visible for ranges a little greater than 5 km, is rendered in crisp detail for ranges well beyond 20 km. Up to a point, as Figure 3 illustrates, there are also clear benefits of SWIR imagery over visible imagery when it comes to dust. The smaller, lighter wind-borne dust particles that hang in the air the longest are transparent to the SWIR, yet continue to obscure in the visible. In perhaps the most dramatic example of the SWIR advantage, Figure 4 shows how the typical San Francisco Bay morning maritime fog and mist is no impediment. Finally, almost as striking is the ability of the SWIR to see through smoke of a forest fire as shown in Figure 5. Similar examples can be found with photochemical smog and other atmospheric obscurants prevalent in many urban environments.

The longer wavelength SWIR provides a distinct advantage over visible while retaining its most intuitive reflected light quality. Even though thermal imagers operate at even longer wavelengths than SWIR, other factors compromise their low atmospheric scattering advantage. In the end, thermal imagers may be good for detection of potential threats, but it takes SWIR to make a positive identification at the longest ranges in all weathers and all environments.

Impact on Military ConOps

From barren deserts to tropical, humid maritime environments, SWIR extends the range at which threats can be positively identified, greatly increasing a warfighter's options. SWIR provides crisper, clearer situational awareness than possible with visible imagery, and enables positive identification out to far greater ranges and under broader sets of weather and environmental conditions, day or night. Intelligence can be gathered by going more deeply into denied territory with SWIR imagers. Sensor-to-shooter timelines are compressed and targeting is now possible with greater confidence to the full range of more weapons systems. Battle damage assessment can be conducted swiftly in the SWIR with its superior ability to see through the smoke, allowing the warfighter to rapidly assess weapon effectiveness post strike.

Figure 4. Comparative SWIR (left) and visible (right) images of a San Francisco Bay Bridge scene with typical morning fog

Figure 5. Comparative SWIR (left) and visible (right) images of an Oregon forest fire scene (images courtesy of Cloud Cap Technologies)

Compact, uncooled InGaAs imagers are opening up the possibilities for deploying powerful new capabilities on next generation military platforms. Network-centric operations in-theater channel digital data from distributed sensors. Thanks to the revolutionary all weather, all environmental SWIR capability and its small footprint, these compact sensors can be deployed on demand, practically anywhere and anytime the warfighter needs. The revolution may only be just beginning, but it is already hard at work denying terrorists their safe haven.

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For the latest in SWIR imaging concepts of operation, visit www.swirconops.com

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