David Lee assesses the value of thermal imaging technology for border security and critical infrastructure protection, and offers advice on selecting the right system for each application

THE HEAT OF

Border security and coastal surveillance are 24/7 operations that can't afford downtime or periods of reduced readiness. Guarding against illegal immigration, smuggling, and terrorism demands reliable long-range threat detection all day and all night. More and more, thermal security cameras have become the visual surveillance sensor of choice for these demanding, high-security missions. Proven as the best 24-hour visual surveillance imaging solutions available for many years, they are a vital component in any truly persistent surveillance design for securing any large border or perimeter that requires constant vigilance. Through dust and smog, even in the darkest nights, thermal cameras let security professionals see intruders and vehicles alike. No matter what they need to see, or where they need to see it from, thermal cameras keep border security personnel seeing clearly.

The tactical and practical advantages of thermal as the best solution around for nighttime security imaging have been known for years. Their downside – until recently – has been that they were more expensive, requiring long budgetary intervals between acquisitions. But the last few years have seen the cost of high-quality thermal security cameras come down dramatically, greatly expanding their use around the security industry in general, and in homeland security and critical infrastructure security applications in particular.

Thermal security cameras let people see what their eyes can't: invisible heat radiation emitted by all objects regardless of lighting conditions. Thermal cameras detect the minute temperature differences between objects, and turn them into video that displays on almost any TV monitor. Because they see heat, not light, thermal cameras are effective threat detection tools in any environment. They can easily detect intruders and other potential hazards to the security of people and infrastructure in any weather, as well as all day and all night.

Thermal cameras don't suffer from the basic limitations of visible-light imaging. First, thermal cameras make pictures from heat, not light, having nothing whatsoever to do with reflected light energy. They see the heat given off by everything under the sun. Everything we encounter in daily life emits heat energy, called a "heat signature," that thermal cameras can see clearly.

Not only does everything have a heat signature, but these heat signatures also create their own contrast, so the thermal energy seen by thermal cameras generally creates a better image at night than during the day. They work just fine during the day – you can see an object as long as there is the tiniest bit of temperature contrast between it and its background – but they work best at night.

Thermal security cameras act as a force multiplier, allowing law enforcement and security operators to react more effectively – responding to threats with the appropriate force, and using agency resources more efficiently. For instance, thermal security cameras have been widely adopted as the imaging technology of choice to answer regulations requiring unbroken video surveillance coverage and 24-hour surveillance, observation, and monitoring of the perimeter and control areas around critical infrastructure facilities and borders.

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Once a security manager has chosen thermal cameras, they are faced with a wide range of choices, however. Midwave or longwave? Cooled or uncooled? What resolution? How big a lens? This can seem like a complicated undertaking at first, but keeping mission requirements as the primary driver instead of technical attributes can help to simplify things considerably. (As an aside, it should be noted that the following information will necessarily deal in generalities. Exceptions exist for many of these generalities, but looking at the broader picture will help to simplify the discussion.)

Thermal security cameras are either cooled or uncooled, referring to whether the infrared detector at the heart of the camera's sensor needs to be cooled to cryogenic

THE NIGHT

Fully-equipped multi-sensor pan/tilt sensor systems can precisely geo-locate anything in its field of view.

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temperatures in order to create an image. Which type of imager is better depends largely on the needs of the specific application; each has advantages and weaknesses. Cooled cameras are more sensitive to small differences in scene temperature than are uncooled cameras, meaning that they can see smaller objects from farther away, making cooled cameras more suitable for extremely long-range imaging in low-contrast environments. But the cryocoolers used in these cameras have moving parts made to exacting mechanical tolerances that can wear out over time, requiring periodic maintenance as they get older. Often, a cooled imager's life-limiting part will be the cooler itself or some component within it.

Uncooled thermal cameras – as the name implies – do not use cryogenic cooling. The most popular uncooled thermal security cameras use uncooled detectors called Vanadium Oxide (VOx) microbolometers. Uncooled sensors are typically sensitive to LWIR energy. Uncooled detectors are manufactured in fewer steps than those used in cooled sensors, use less expensive vacuum packaging, and – most significantly – don't require costly cryocoolers.

Uncooled cameras have fewer moving parts and tend to have much longer service lives than cooled cameras under similar operating conditions, making them well-suited to security applications, which often require continuous camera operations. A cooled camera would require service after 1-2 years of such operation, while an uncooled camera could run uninterrupted for much longer.

With all of the advantages of uncooled cameras in mind, it begs the question: why use cooled cameras at all? The answer is that, as detection range requirements increase past a few miles, cooled thermal security cameras become more cost-effective because of the lens designs involved. One of the biggest cost drivers of a long-range uncooled camera system is the lens. As effective range requirements increase, the lenses for uncooled camera systems become so expensive that it can often be cheaper to use a cooled thermal security camera with an equivalent focal length lens. Therefore, short- to extreme mid-range imaging can usually be done most cost-effectively with uncooled thermal security cameras, while their cooled counterparts are the best solutions when long-range imaging

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Thermal security cameras are available in dome (above left), fixed-site (above centre), and pan/tilt (above right) configurations

Even in bright daylight, camouflaged clothing allows people to hide from visible-light cameras, but they can't hide from thermal

performance is called for.

Thermal security cameras come in a variety of configurations, including fixed-site cameras and multi-sensor pan/tilt systems. As with the sensor differences just discussed, the different configurations each have their unique plusses and minuses. Fixed-site cameras are obviously used to watch over defined areas, typically access points and areas of special concern or vulnerability. Because of their increased range capability compared to visible-light cameras, a handful of fixed-site thermal security cameras can cover an area that would require dozens of CCTV cameras.

Multi-sensor pan/tilt systems commonly have longer lenses that are more sensitive to being buffeted by the wind, so they often include some type of stabilisation capability, be it physical stabilisation of the pan/tilt mechanism done with internal gyroscopes, or electronic image stabilisation. High-performance systems will also include laser rangefinder and digital magnetic compass payloads that allow the sensor package to precisely geo-locate anything in its field of view.

The answer to the question, "Which one is right for me?" is usually both/and, not either/or. Integrating fixed-site and pan/tilt camera systems together creates a synergy realised in much greater security than either could provide alone. Often, fixed site cameras and pan/tilt cameras are networked together with a video analytics package so that intruders detected by a shorter range fixed-site camera installed along a perimeter can be investigated more thoroughly with the longer range pan/tilt camera installed in a more central location. Because of their high-contrast video output, security professionals have found that thermal security cameras work very well with video analytics, providing more reliable alarming with fewer false reports than visible-light cameras, even during the day.

The mission of securing a nation's borders is challenging for many reasons, chief among them being the sheer size of the area that needs to be effectively monitored and patrolled. Vehicle-based platforms need to be able to operate independently, while still integrating with a central command-and-control facility so that sector commanders can reposition their border security assets as the tactical situation demands.

As a standalone system, or as part of an interconnected network, border surveillance vehicles can combine ground surveillance radar, thermal imagers and other sensors to detect threats as far away as 25 kilometres or more. Typically integrated with pre-configured command and control software, they give sector commanders real-time threat assessment and rapid-response capability.

So what conclusions can we draw? Thermal security cameras offer the best 24/7 imaging range performance available. They are easily networked and work better with video analytics packages than other "lowlight" imaging solutions. They come in a variety of technologies and configurations, providing a solution for any high-security installation or border. Finally, they are inexpensive to operate, do not require the installation of auxiliary lighting infrastructure, and their acquisition costs are projected to continue their downward trend creating the "perfect storm" of affordability and return on investment.

Taking into account their imaging performance, flexibility, networkability, and cost, thermal security cameras provide the best technology available for 24-hour video surveillance of the high-security facilities and borders patrolled by homeland security.

David Lee is a writer and editor with nearly 20 years of experience designing, installing, and operating thermal imaging systems around the world.