Swiss iPVision thermal cameras introduction

Cooled versus uncooled thermal cameras for long-range surveillance

Whether securing a country's borders, or the fence line of a large industrial facility, in daylight, low-light and total darkness, thermal security cameras are the perfect solution.

There are many cooled and uncooled thermal camera systems available for these applications. This technical note describes these two classes of long-range thermal camera systems, and explains the costs and benefits associated with each.

Night and day, in good weather and bad, hiding from a thermal security camera is no easy task.

Cooled thermal security cameras

A cooled thermal camera's imaging sensor is integrated with a cryocooler. The cryocooler lowers the sensor temperature to cryogenic temperatures. This drop in sensor temperature is necessary to lessen thermally induced noise to a level below that of the signal from the scene being imaged.

Cryocoolers have moving parts made to close mechanical tolerances that wear out over time, as well as helium gas that slowly works its way past gas seals. Therefore, cryocoolers need to be rebuilt after 8,000-10,000 hours of use.

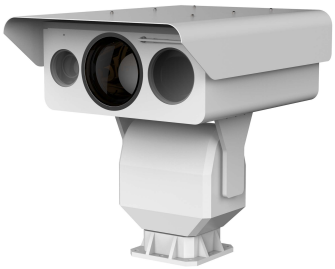
A Cryocooler

Cooled thermal cameras are more sensitive to small differences in scene temperature than are uncooled cameras, making cooled cameras more suitable for extremely long-range imaging in low-contrast scenes. The higher the thermal contrast, the easier it is to detect targets against a background that may not be much colder or hotter than the target.

Uncooled thermal imaging cameras

Uncooled infrared cameras do not use cryogenic cooling. A common detector design is based on the microbolometer, a tiny Vanadium Oxide resistor with a large temperature coefficient on a silicon element with large surface area, low heat capacity and good thermal isolation.

Changes in scene temperature cause changes in the bolometer temperature. The bolometer then converts these inputs to electrical signals and processes them into an image. Uncooled sensors typically work in the Longwave infrared (LWIR) band of 7 to 14 microns, where terrestrial temperature targets emit most of their infrared energy.



IPV-35x140 is a thermal imaging camera with two uncooled microbolometers for mid- to long-range surveillance.

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Uncooled cameras are generally much less expensive than are their counterparts, cooled infrared cameras. The sensors can be manufactured in fewer steps with higher yields relative to cooled sensors, less expensive vacuum packaging, and uncooled cameras do not require cryocoolers, which are very costly devices.

The Swiss IPV-HRC-40 x 480 is an example of a thermal imaging camera with cooled Indium Antimonide *(InSb) detector*

Uncooled cameras have fewer moving parts and tend to have much longer service lives than cooled cameras under similar operating conditions. Security applications often require continuous camera operations. A cooled camera would require service after 1-2 years of such operation; an uncooled camera could work uninterrupted for years.

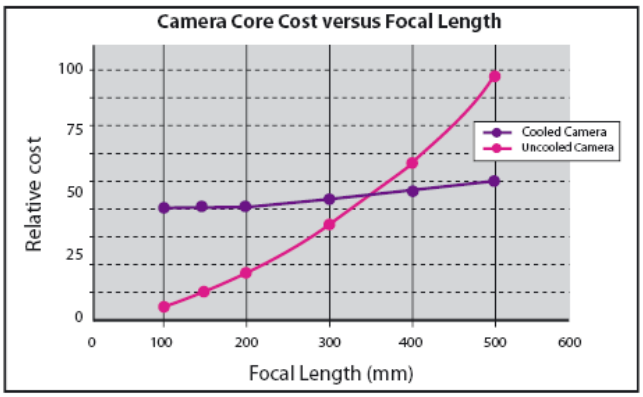
Cooled or uncooled? What to choose?
With all of the advantages of uncooled cameras in mind, it begs the question: why use cooled cameras? The answer: when standoff ranges reach 5km or greater, cooled thermal cameras systems quickly become more cost-effective.

Note the emphasis on the word "systems" – the camera is only one component of an imaging "system". 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 bulky and expensive that it can often be cheaper to specify a cooled camera with an equivalent focal length lens.

Why are lenses so much more expensive for uncooled systems at long focal lengths?
It has to do with another crucial lens parameter, the f/number. The f/number determines the light gathering power of the lens and therefore affects the sensitivity of the camera system.

The f/number of an optical system is the ratio of the focal length of the lens to the diameter of the front lens element. An f/2 lens with a 500mm focal length must therefore have a 250mm diameter front lens element. That front lens element is very expensive and approaches the limits of manufacturability for germanium, due in part to the difficulty of making a large enough optics-grade blank out of raw germanium material.

As the focal length of a lens is increased, the diameter of the front lens element must be increased to keep the system f/ number constant. An uncooled camera must run at a low f/number (typically 1.4-2) to have sensitivity comparable to that of a cooled camera. Higher f/numbers reduce uncooled camera sensitivity.



In contrast, a cooled camera system can be operated at f/numbers of f/4 and higher without significantly compromising system sensitivity. This is because the exposure time or integration time of a

cooled camera is a parameter that can be increased to make up for reduced light throughput. Uncooled cameras do not have this flexibility.

Conclusion:
Long-range thermal surveillance applications require long focal length lenses. The cost of lenses increases rapidly with focal length for uncooled camera systems and rather slowly for cooled systems. As a result, even though the cost of a cooled camera core is much higher than an uncooled core, the system cost (core plus lens) for uncooled surpasses cooled system cost at a focal length on the order of 350mm. Useful imaging of man-sized targets at long ranges requires focal lengths that exceed 350mm. Therefore, long-range imaging of man-sized targets is less expensive with a cooled camera system, at least when only considering system acquisition cost.

It is important to take the 8,000-10,000 hour lifetime of cryocoolers into account when trying to arrive at the best solution. If the cryocooler needs a servicing every 2 years, and the cost is 10% of the total system, then the 4-year cost of the cooled system is really 1.2X the initial system cost.

Having more than 20 years of experience with thermal imaging cameras, and producing both cooled and uncooled systems, Swiss iPVision Systems can always provide you with the necessary information to make a well-informed decision for your particular application.