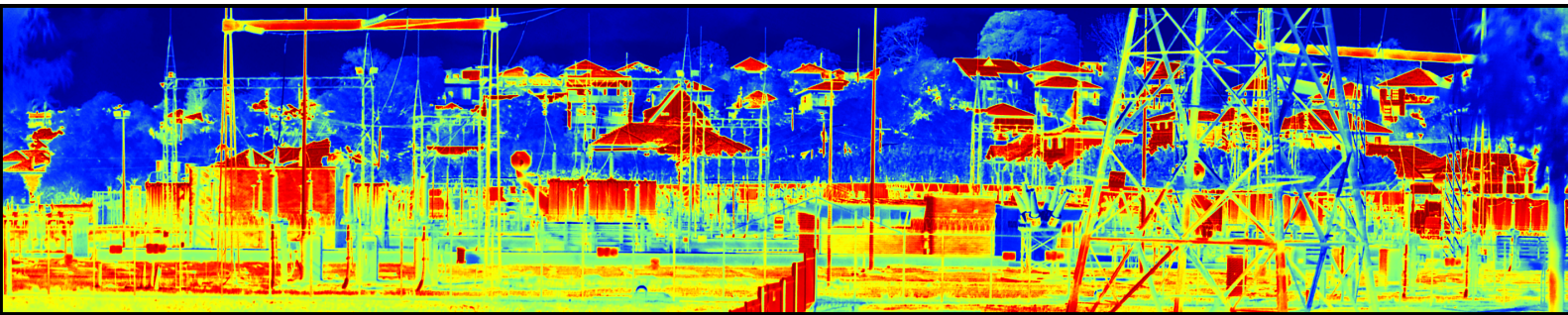


RobotEye RELW60 Thermal LWIR Thermal Imaging System



Condition-Based Maintenance Monitoring and Security for Critical Electrical Infrastructure

Electrical substations and other critical electricity infrastructure provide the power that everyone in the community depends on. As such there is an obvious precedence on ensuring these systems are reliable. Regular monitoring of the equipment as part of a condition-based maintenance program is necessary for avoiding costly and highly disruptive system failures and prolonging equipment life. In addition, due to the dangerous high voltage accessible at these sites and the importance of electrical power systems to society these key pieces of electrical infrastructure can present serious risks through misadventure or even be targets for deliberate interference. Therefore, it is imperative to closely monitor the physical security of the site in addition to the condition of the equipment.

Thermal images have long been used as a method of security monitoring due to their ability to identify the presence of warm bodies in the absence of visible light. More recently however, thermal imaging has been used as a solution to monitor the condition of electrical equipment due to its ability to reveal early signs of potential malfunction in the form of overheating that are not detectable by the human eye. In this way equipment can be monitored regularly from a remote point making the job safer and more efficient. The combination of these capabilities makes thermal imaging an ideal solution for monitoring an electrical substation.

Due to the high cost and low resolution of thermal imagers, fixed or pan-tilt thermal camera systems suffer from the need to compromise between field of view and range. Ocular Robotics RELW60 long wave thermal imaging system with its embedded RobotEye technology delivers the best of both worlds. The system's unprecedented combination of speed and precision allows the expensive thermal pixels to be concentrated in a small field of view to provide long range, while at the same time enabling the rapid and precise directing of the camera's field of view over a wide area.

The simultaneous wide area and long-range thermal imaging delivered by the RELW60 means that the number of thermal imaging systems needed to cover a site is significantly reduced, which also reduces installation costs and ongoing maintenance. Making the RELW60 a complete and cost effective, high-performance security and pre-emptive maintenance monitoring system. The level of speed and precision unique to the RobotEye, far more efficiently achieves the established security and equipment monitoring capabilities of alternative thermal imaging approaches. Furthermore it introduces new capabilities not possible with traditional handheld, fixed or pan tilt operated cameras; such as producing frequent high-resolution wide area thermal images and the simultaneous tracking of multiple intruders.

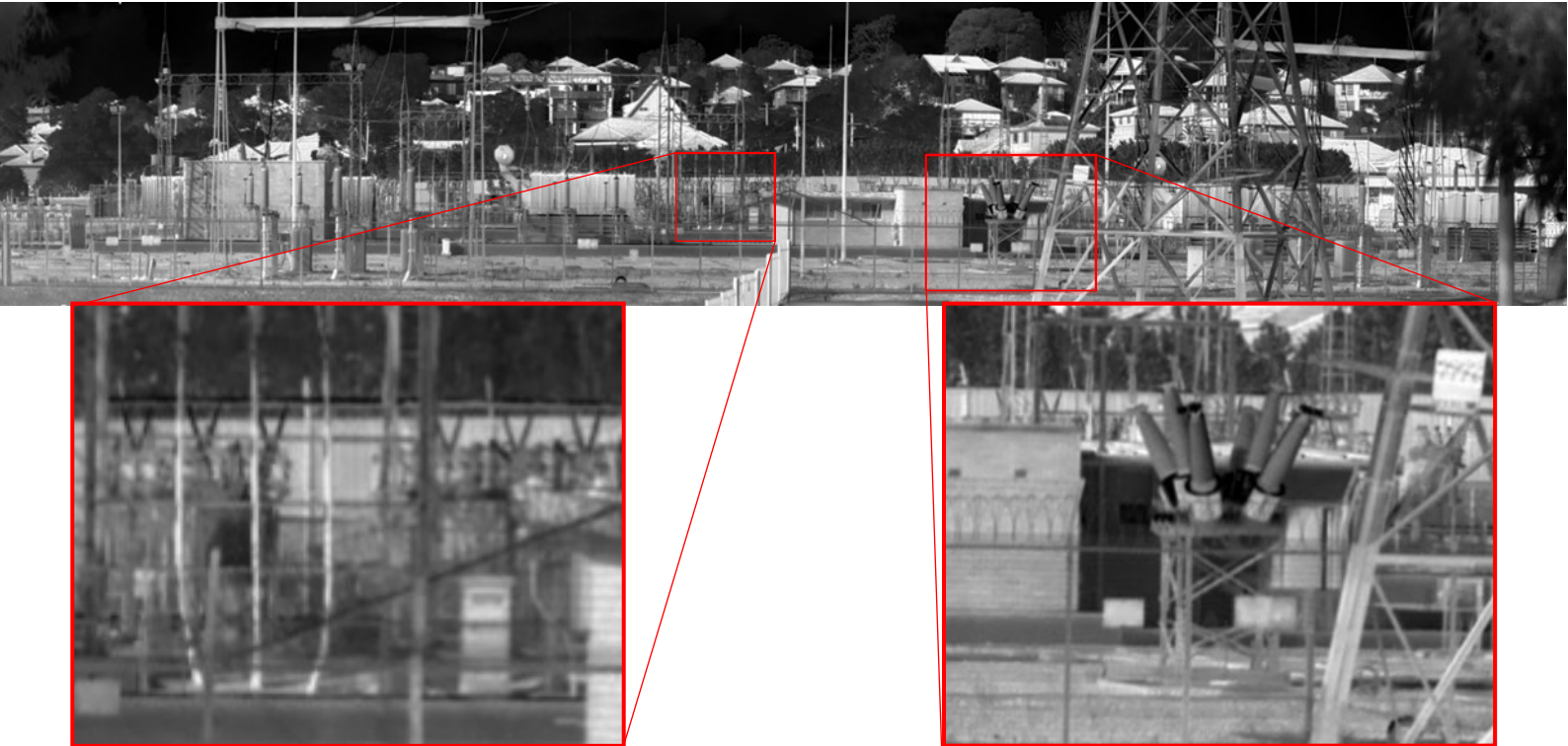


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Wide Area, High Resolution Site Maps



A thermal mapping of the entire substation contains valuable information regarding the condition of the equipment throughout the site. This can inform the maintenance team about specific areas that need to be monitored closely or in fact need inspection or repair. The RELW60's precision pointing means that equipment is reliably registered in the same location with each pass, enabling automated analysis of equipment condition.

The RobotEye RELW60 is able to capture an entire large-scale substation in a matter of seconds. The speed and precision of the RELW60's pointing means that even while using a camera with a narrow field of view lens, accurate wide area images can be composited with no compromising on speed or image quality in the frame capturing process. The result is a high-resolution panorama that provides a detailed view of the entire site. The efficiency with which the RELW60 captures these panoramas means the process can be repeated with high regularity as only one of several functions that the system might be tasked to perform.

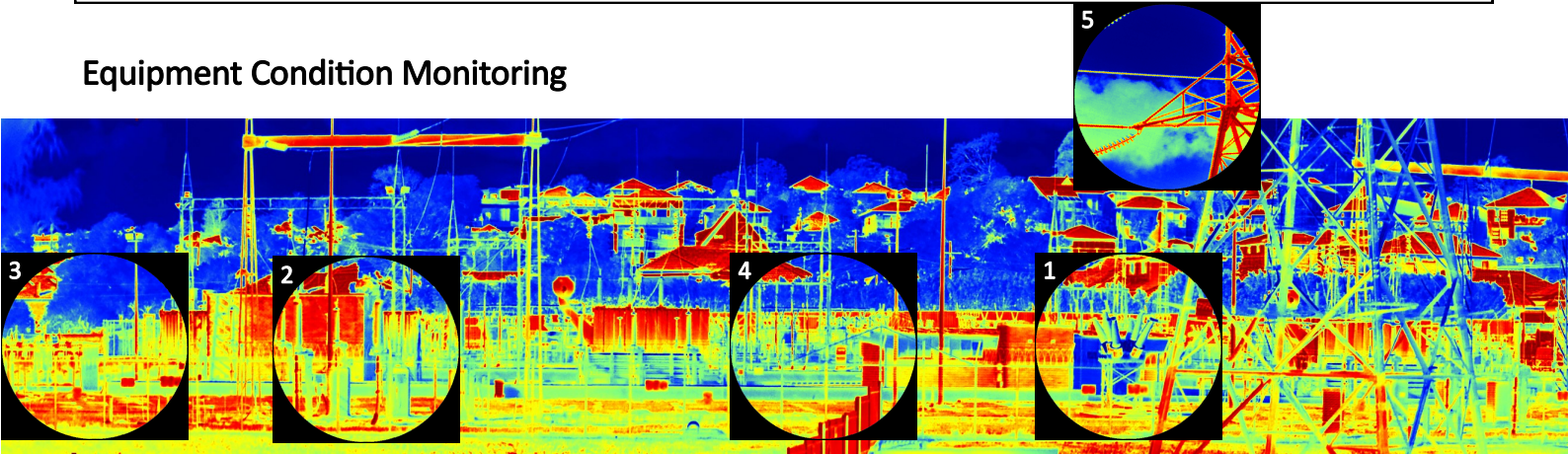
The panorama pictured above presents a 130m wide section of the substation. The RobotEye RELW60 completed the set of 13 individual frames in 1.08 seconds (12 frames per second). The inset frames display the level of detail contained within the image. The circuit breaker in the right inset image is 95m away from the capture point, whereas the equipment in the left inset image is 150m away.

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Equipment Condition Monitoring



Where it is desired to closely monitor specific areas or equipment within the site, RobotEye provides the ability to specify multipoint paths for the RELW60 to follow. With RobotEye these paths can be completed with amazing speed while maintaining precise pointing at the desired target.

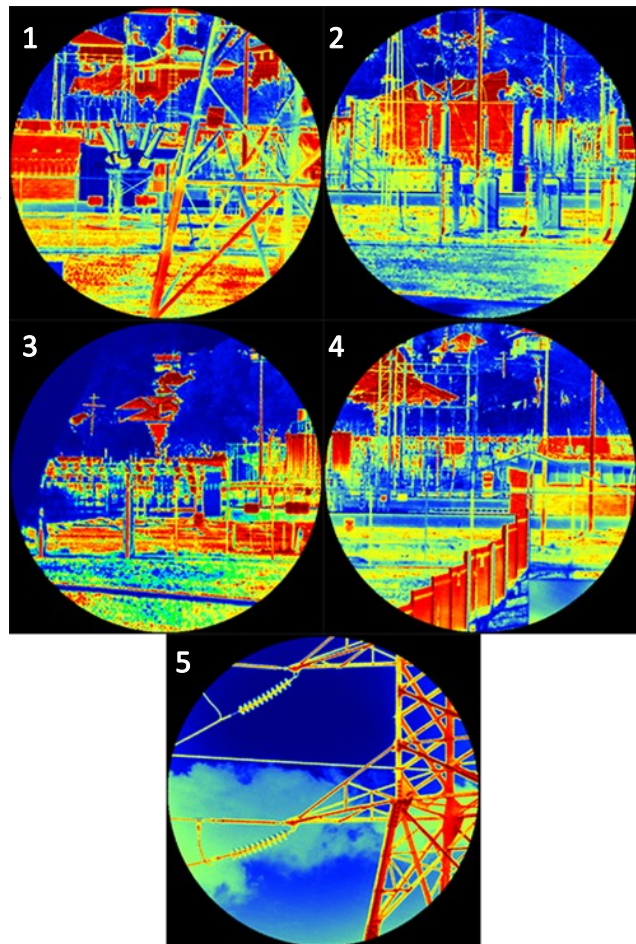
In the example shown, the RobotEye RELW60 was able to cycle through all five, distinct image locations in 1.4 seconds. The 5 images shown here demonstrate how the RELW60 can provide useful information by giving detailed temperature profiles of the various equipment. Any overheating in the equipment will be identified in these images giving the maintenance team early warning signs of impending failures, critical in avoiding irreversible damage to equipment and lengthy power outages.

Labour intensive and infrequent manual inspections using handheld thermal imagers are a costly process and may miss the development of rapidly evolving problems.

The use of fixed or pan-tilt thermal imaging systems requires the installation and maintenance of several times the number of cameras with only limited ability to multitask those resources.

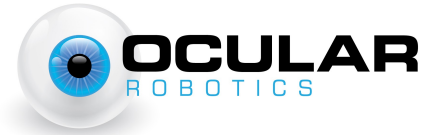
Pre-emptive condition-based maintenance based on the Ocular Robotics' RELW60 Thermal Vision system requires a relatively small number of units placed around the site to deliver:

- Frequent wide area high resolution thermal panoramas from key perspectives for both thermal and security monitoring
- Targeted monitoring of key equipment with adaptive system behaviour in response to prescribed events such as potential fault conditions
- Building of site thermal profile statistics to distinguish normal condition thermal cycles due to load and weather from fault conditions
- Dynamic perimeter and internal security monitoring
- Automated condition analysis



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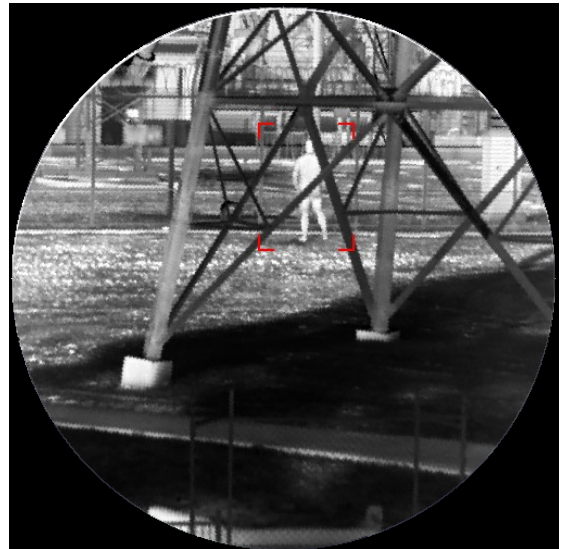
Perimeter Security Monitoring



The physical security of a substation is vitally important. Substations can be the target of copper wire theft, which is detrimental not only as a financial loss, but as a reliability loss to the system. They represent a very high risk of injury or death through misadventure for those that gain access illegally. Substations and other critical electricity infrastructure can even be a target for attacks from those wanting to cause disruption to the community.

The RELW60's speed and precision enables this thermal sensing resource to be leveraged across multiple tasks adding further value to an investment in pre-emptive maintenance monitoring.

Frequent and rapid monitoring of the perimeter can easily be integrated into other tasks being performed by the system without impacting the system's core pre-emptive maintenance monitoring role. Roboteye RELW60's capabilities are such that, if potential intruder activity is detected, even multiple intruders whether human, vehicular or airborne at different locations moving in different directions can be monitored simultaneously.



The high resolution and precise pointing of the RELW60 delivers a clear image of a potential threat. Allowing for a high level of discrimination between possible threats and false alarms from animals or other things that may have come into the vicinity.

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Thermal Imaging Capture System Comparison

Capture System	Capabilities	Advantages	Disadvantages
Handheld	<ul style="list-style-type: none"> Monitor electrical equipment for overheating 	<ul style="list-style-type: none"> Portability 	<ul style="list-style-type: none"> Labour intensive operation Time inefficient Infrequent monitoring intervals Operator error Potentially unsafe to be in close proximity to faulty electrical equipment
Pan-Tilt	<ul style="list-style-type: none"> Monitor perimeter for security Monitor site for hotspots 	<ul style="list-style-type: none"> Can be monitored remotely 	<ul style="list-style-type: none"> Would require many cameras to effectively cover a large site Slow to capture the various images required for effective monitoring
RobotEye RELW60 Thermal Vision System	<ul style="list-style-type: none"> Capture Megapixel 360° thermal panoramas of large-scale sites in Seconds Monitor specific equipment and assets with speed and precision Frequently monitor the entire perimeter for potential intruders Track multiple intruders in real-time Build statistical thermal profiles for different operating and environmental conditions System operation multitasking Ability to automate the above capabilities 	<ul style="list-style-type: none"> Extreme speed and precision allows for a narrow field of view delivering long range and simultaneous wide area coverage High efficiency allows all listed capabilities to be performed without sacrificing frequency Automated capabilities allow for multiple sites to be monitored from a single central location Large sites covered with low numbers of RELW60 systems Learnt thermal profiles provide enhanced fault detection performance 	<ul style="list-style-type: none"> Compared to handheld monitoring, significant initial investment per site, which will inevitably pay for itself through improved early fault detection, labour and maintenance savings, theft prevention, and improved safety