Beyond light we see heat

HIGH PERFORMANCE
CAMERAS FOR
RESEARCH, SCIENCE
& ENGINEERING

Thermal Vision
Research

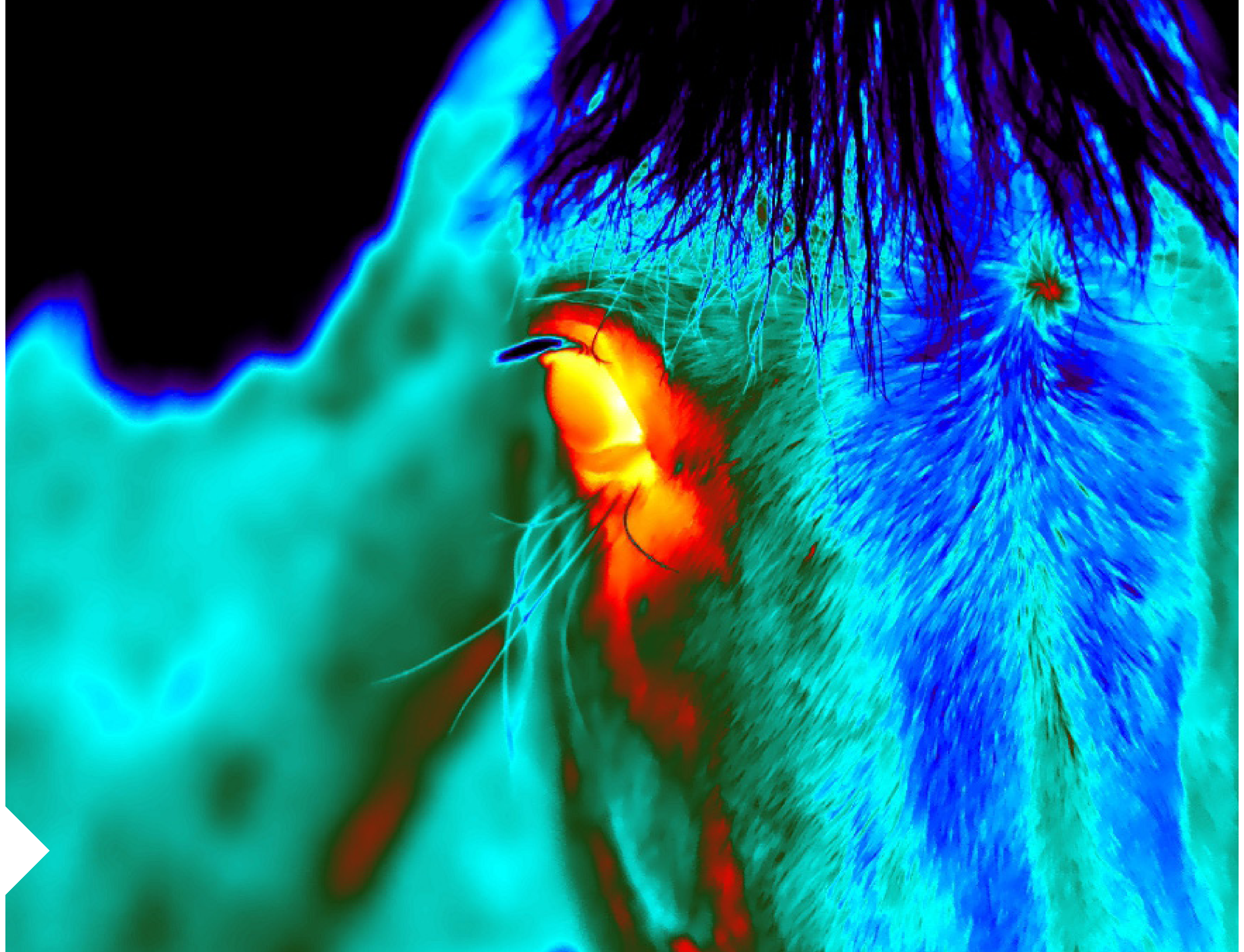

IMAGE TAKEN WITH: FLIR T1020 - THERMAL CAMERA 1024 X 768 RESOLUTION

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IMAGE TAKEN WITH: FLIR T650SC - THERMAL CAMERA 640 X 480 RESOLUTION

About us

Thermal Vision Research Ltd (TVR) has over 10 years' experience in the thermal imaging market. Founded by entrepreneur Matthew Clavey, we supply FLIR's range of specialist IR thermography cameras for the **research and development (R&D)** market.

Whether you work for a blue chip company, a national organisation or are an engineer, scientist or inventor developing a project on a smaller scale, we'll be able to tailor a camera package to suit your project and budget. This brochure is an introduction to the **services we provide**, but nothing compares to the personal approach.

What makes us unique is that many of our cameras are not widely available in the UK – and combining this with the tailored software packages and the expert technical support our team provides, we offer a bespoke solution to our clients which cannot be matched by any other UK distributor.

From **equipment** and **network set ups**, to **training** and **evaluation** support, we pride ourselves on bringing a personal service to experienced and novice technicians alike, across all industry sectors. Our clients challenge us to develop and apply **thermographic solutions** for every application you can think of, from non-destructive testing to paper processing, or consumer appliance design, to ballistics. But this is what we do best – and it's why industry leader **FLIR** continues to engage us as a distributor.

▸ Please get in touch, arrange for us to visit and we can show you how IR thermography could be your problem-solver.

OVERVIEW: FLIR X8500sc MWIR

Detector Type
FLIR indium antimonide (InSb)

Dynamic Range
14-bit

Accuracy
±2°C or ±2% of reading

NETD
<20 mK

Automatic Gain Control
Manual, Linear, Plateau equalization, ROI, DDE

Spectral Range
3.0 – 5.0 µm /1.5 – 5.0 µm

Size (L x W x H) without Lens & Handle
249mm x 158mm x 147mm
(9.8" x 6.2" x 5.8")

Weight (without Lens & with Handle)
6.35 kg (14 lbs)

The basics

We never like to assume what our clients may or may not know about **infrared (IR) thermal imaging** – so we'll start with the basics. Feel free to skip ahead if you need to.

The concept of **IR thermal imaging or thermography** is very simple: **We can see light**, but we can't see radiation, or heat. This is because our vision is limited to a very small portion of the electromagnetic spectrum.

Thermal imaging is the process of converting that infrared radiation into visible images, enabling us to see and measure the thermal energy which is being emitted. To explain in a little more detail, unlike visible light, in the infrared world everything with a temperature above absolute zero emits heat. Even very cold objects, like ice cubes, emit infrared.

The higher the object's temperature, the greater the IR radiation emitted. An infrared camera is a non-contact device, similar in construction to a video camera. It produces images of invisible infrared or 'heat' radiation by detecting the energy being emitted and converting it into an electronic signal. This is then processed to produce a thermal image or video, which enables us to precisely examine materials or component parts of a given subject.

Nearly everything gets hot before it fails, which is why IR cameras are an extremely popular, cost-effective, valuable diagnostic tool in many applications. And as we look at ways to improve manufacturing efficiencies, manage energy, improve product quality and enhance worker safety, the capabilities and opportunities for infrared cameras are on the increase.

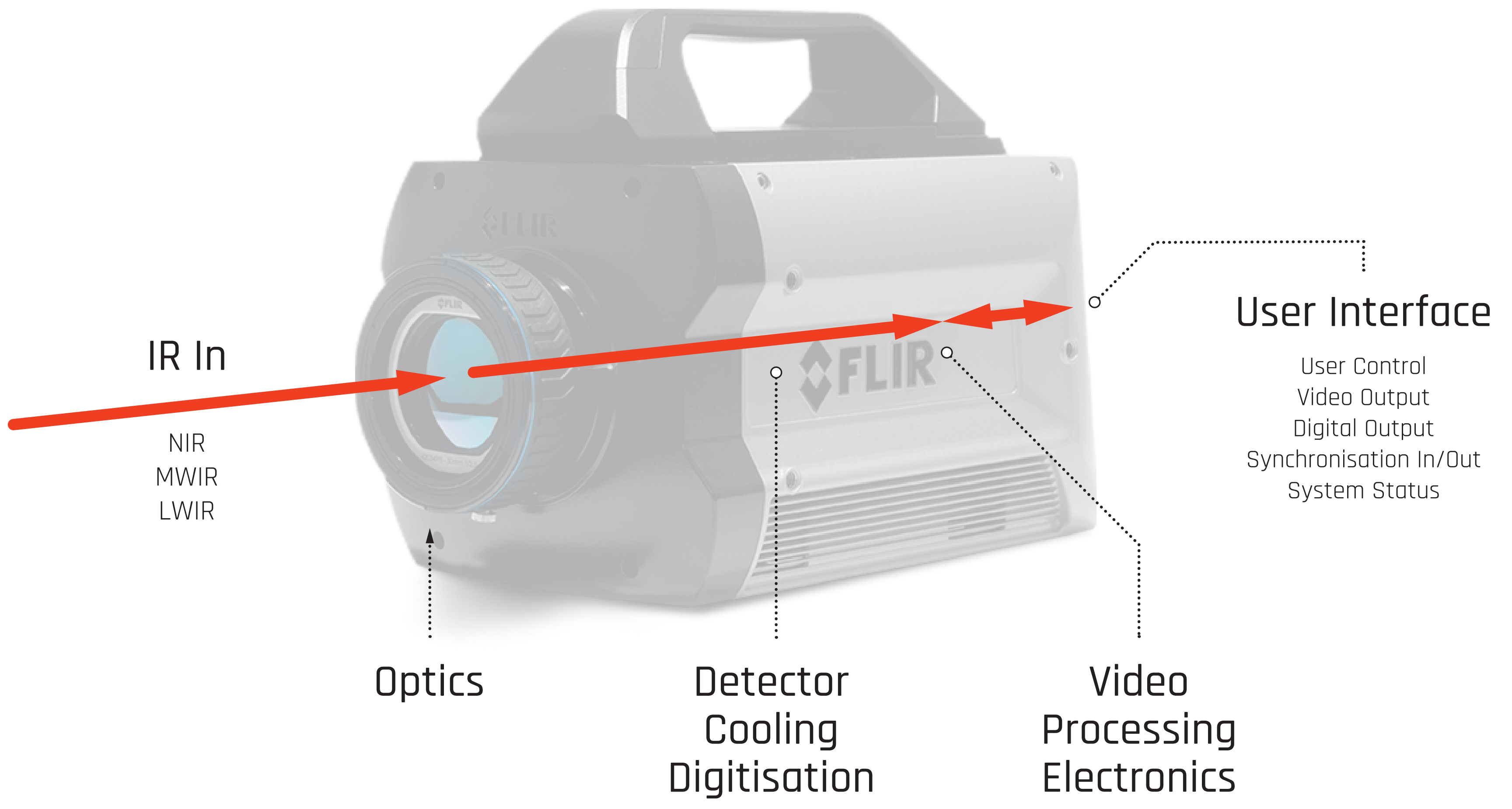


DIAGRAM: Simplified diagram of an IR camera.

IMAGE TAKEN WITH: FLIR T650SC · THERMAL CAMERA 640 X 480 RESOLUTION

Building your camera package

OVERVIEW: FLIR A6260sc

Detector Type
Indium Gallium Arsenide (InGaAs)

Dynamic Range
14-bit

Accuracy
±1°C or ±1% of reading

NETD
NA

Automatic Gain Control
Manual, Linear, Plateau equalization, DDE

Spectral Range
0.9 – 1.7 µm

Size (L x W x H) without Lens
216mm x 102mm x 109mm
(8.5" x 4.0" x 4.3")

Weight (without Lens)
2.3 kg (5 lbs)

BUILDING YOUR CAMERA PACKAGE

The IR camera you choose has to be **fit for purpose**, but how do know which one is right for your specific application when there are so many to choose from? By working with us, we'll take you through a **simple process** to ensure we find **exactly** the right camera package to **suit your requirements**.

1 You and your camera

The first and most important part of your camera selection process is for us to fully understand what you need a camera to do. We'll start by talking to you about your specific requirements, either over the phone or in person, before exploring some more detailed discussion points.

2 Temperature measurement

IR cameras are generally used to measure the temperature changes of a particular object. By knowing the temperature range of that object and the temperature resolution you want to achieve, we can narrow down which types of infrared cameras would suit you best.

▸ Temperature range
By this we mean how hot or how cold your project will become in a given setting. For example, an aircraft sitting on a runway might have a body temperature of 25°C and an engine temperature of 500°C – so you need an IR camera which can measure from 25°C to 500°C at the same time.

▸ Temperature resolution
This is sometime called temperature sensitivity, or Noise Equivalent Delta Temperature (NEDT), and is the smallest temperature difference you need to be able to measure. IR cameras sensitivities can range from 0.020°C to 0.075°C, depending on the camera's detector type.

FLIR Camera Model	Detector Type	Thermal Sensitivity/NEDT	Temperature Range
A655sc	Microbolometer	<30 mK	-40°C to 650°C (-40°F to 1202°F) Optional Range: Up to 2000°C
A6751sc MWIR	Indium antimonide (InSb)	<18 mK	-20°C to 350°C (-4°F to 662°F) Optional Range: Up to 1500°C, 2000°C, or 3000°C
X6901sc LWIR	Strained Layer Superlattice (SLS)	<40 mK	-20°C to 650°C (-4°F to 1202°F) Optional Range: Up to 1500°C, 2000°C, or 3000°C

TABLE: Temperature range and resolution of common IR cameras.

3 Data capture speed

Data capture speeds can vary enormously - we need to consider exposure times, frame rates and total recording time to ensure your camera is capable of capturing the right data.

▸ Exposure time
Referred to as its 'integration time', this is how quickly an IR camera can capture a single frame of data. The shorter the exposure time, the less likely there is to be any blurring, however the image may be under-exposed. For longer exposure times, more heat data can be captured, but if the object is moving, the image may be blurred. Camera selection therefore has to be combined with thermal resolution, considering the required exposure time with the sensitivity of the camera.

▸ Frame rate
This means how many thermal images you can capture, per second. IR cameras with fast frame rates allow you to capture the thermal signatures of fast-moving targets. Shorter exposure times allow for faster frame rates and overall frame rates can vary from a few frames per second, to thousands of frames per second.

▸ Total record time
You might want to capture data at high speed for long periods, at high speed for short bursts, or at slow rates for hours. There are plenty of data recording options available and we'll work through these with you as part of your selection process.

FLIR Camera Model	Detector Type	Exposure Times	Frame Rate
A655sc	Microbolometer	12 milliseconds	50 Hz
A6751sc MWIR	Indium antimonide (InSb)	1.0 milliseconds	125 Hz
X6901sc LWIR	Strained Layer Superlattice (SLS)	0.2 milliseconds	1000 Hz

TABLE: Frame rates and exposure times of common IR cameras.

BUILDING YOUR CAMERA PACKAGE CONTINUED...

4

Lens selection

To get the best thermal imagery and most points of measurement for your specific project, you need a lens which fills your field of view with exactly what you need to see – and provides the best spatial resolution to ensure you capture even the smallest of details.

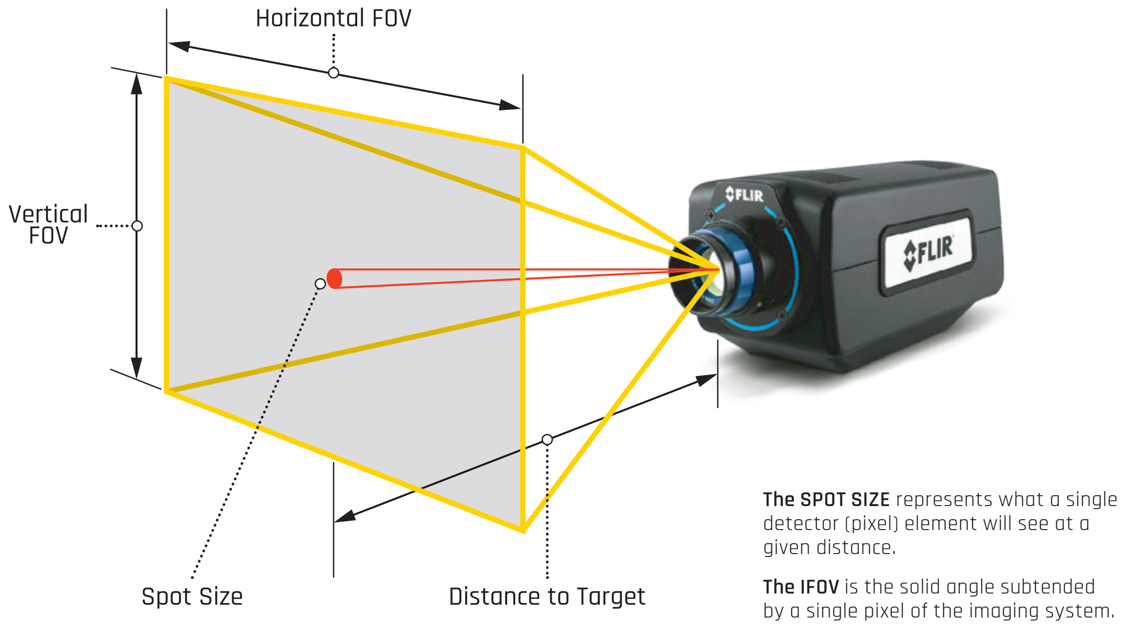
Spatial resolution

Also known as the Instantaneous Field of View or IFOV, this refers to the smallest physical detail you can detect on your target - the smallest area a single camera (detector) pixel covers. The closer you move to an object, the smaller the area a pixel will detect.

Field of View

Your field of view changes as you look at objects from further away – so you will have fewer pixels on your target when you're imaging from a distance. Ideally, you want your object to fill your field of view, but sometimes this isn't possible if your subject is particularly hot, or poses danger.

When we know what you want your spatial resolution and field of view to be, then we can help you choose the right lens, or set of lenses to capture the data you need.



The SPOT SIZE represents what a single detector (pixel) element will see at a given distance.

The IFOV is the solid angle subtended by a single pixel of the imaging system. It varies by camera FPA dimensions and lens combination.

SPOT SIZE = IFOV x Distance to Target

DIAGRAM: Relationship between Field of View and Distance.

5

Detector selection

Different detectors sense infrared energy in different wavelengths or wavebands. So, depending on your application, the waveband over which your IR camera senses energy can have a significant impact on your measurement results.

For example, if you need your camera to measure the filament of a lightbulb, you need a detector which operates within the transmission window of the lightbulb's glass. Use the wrong detector and you'll simply capture data for the glass instead of the filament.

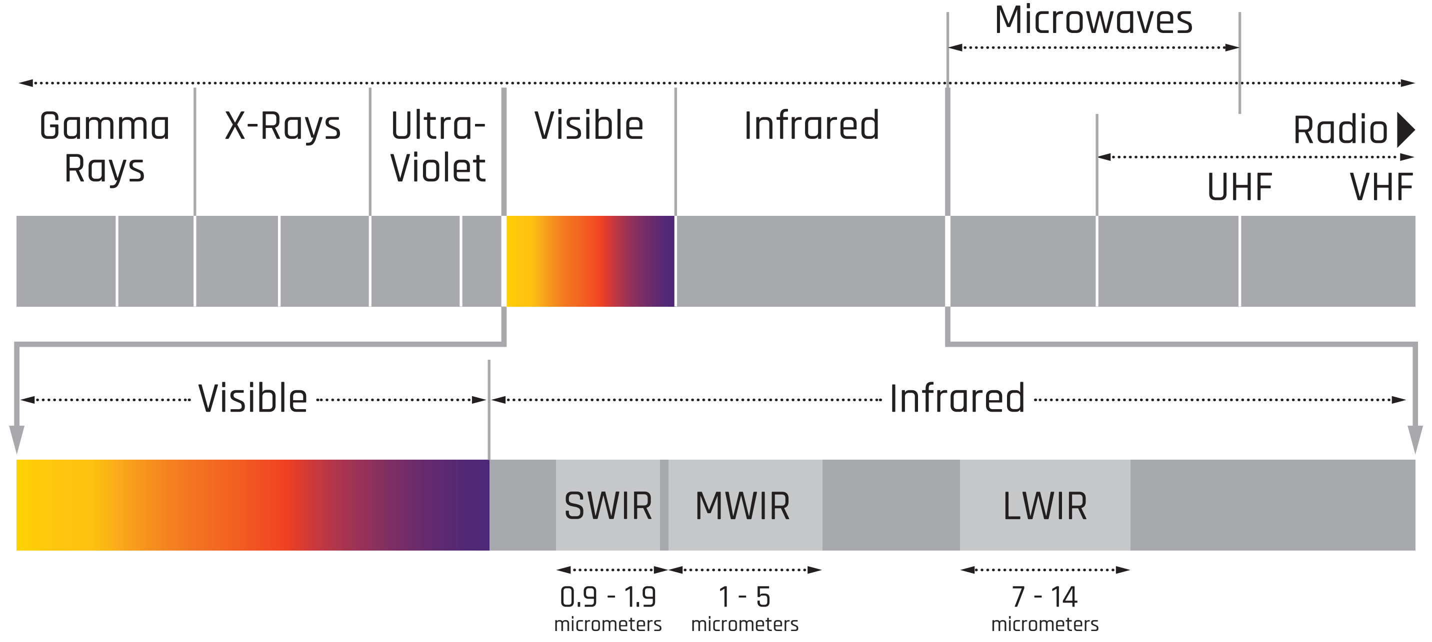


FIGURE: Atmospheric transmission for infrared energy.

BUILDING YOUR CAMERA PACKAGE CONTINUED...

6 Data reporting

Camera hardware and data collection is only half the story, our expert team can also help you find the best way of analysing and reporting data.

▸ Data analysis
Just by looking at an IR image you can quickly see areas of hot and cold, but by applying techniques for image enhancement, emissivity adjustment or image subtraction, you can gain a detailed understanding of the thermal changes taking place on a target object.

Image enhancement for example, allows you to draw out subtle temperature differences. Or removing a baseline image from an energised image allows you to expose extremely small temperature variances.

It's likely you'll also need to share your data with others, so having an IR software package which allows data export may also be important.

▸ Superframing
This involves cycling the IR camera through up to four unique temperature ranges and sequentially capturing data from each range. By using software such as FLIR ResearchIR Max you can present this data as movie files.

Superframing only works with certain cameras and software though – and we would consider this as part of your selection process.

7 Accessories

From protective enclosures to infrared windows, we can advise on the right kit to use with your camera, tailored to the environment it will be operating in.

For mounting your camera outdoors or in manufacturing environments, you may want to consider an enclosure with a special infrared window which is optimised for your specific camera and detector.

Another common accessory is a cable extension for use where your camera is located a long distance away. We can explore options with you for transmitting your thermal data at full frame rates, for miles if necessary.

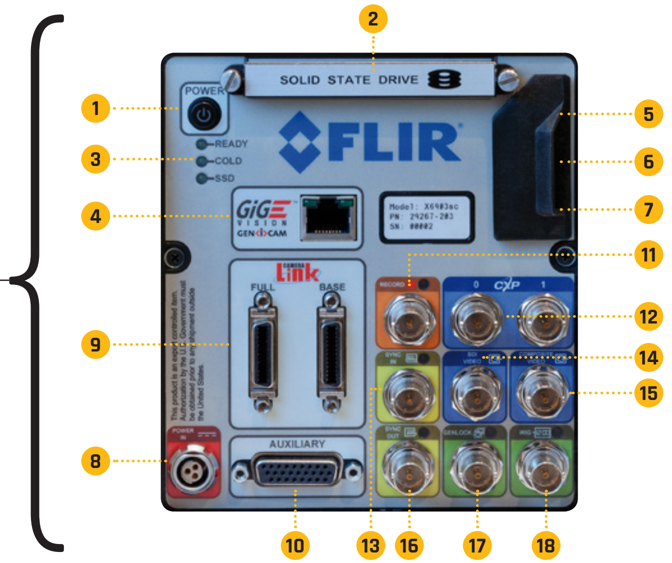
8 Support, training and warranty

Finally, from learning how to switch your camera on, to bespoke measurement techniques, we can provide as much or as little support as you need.

Warranty packages can be tailored to extend from the standard one year to five, or to provide 24hr swap out options for production line applications, where downtime is critical.

CONNECTIONS

There are many ways in which you can connect your camera for data capture and transfer. The image shown here uses the X6900sc as an example, though user manuals specific to each camera would provide information relevant to individual products.



1. Power switch: This illuminates when camera power is 'On'.

2. Solid State Drive (SSD): Your camera may be supplied with a suitable SSD, formatted to provide the best possible data transfer.

3. Status lights: These help you understand how the camera is operating. The 'Cold' light tells you when the camera has reached its operating temperature.

4. Gigabit Ethernet: This is for connecting with your PC and can be used for data acquisition and/or camera control.

5. MicroSD: Not currently available.

6. USB client: This is a Command and Control port for user interface – it can also be used for firmware upgrades provided by FLIR.

7. HDMI video: This is active when HD video mode is selected. It's compatible with standard HDMI cables.

8. Power interface: An AC-DC power convertor will be supplied with your camera. Guidance will be provided if you choose to use your own DC power supply.

9. CameraLink video output: A standard data interface for high end visible and IR cameras.

10. Auxiliary connector: This provides access to a range of alternative input and output signals.

11. Record trigger: This allows the camera to start recording. The LED will flash when the recorder is ready.

12. CoaXPress video output: This is a standard interface for high speed digital video data and can support flexible image sizes and frame rates.

13. Sync in: This can be selected for the camera to operate as an external Frame Sync to clock frames.

14. HD-SDI: This is a standard HD video interface which can transmit either 1080p or 720p video over distances up to 300ft.

15. Composite video output: BNC connector point.

16. Sync out: This works together with 'Sync in' and can be used to synchronise other events when the camera is in 'Free Run' mode.

17. Genlock input: This allows the camera to synchronise the active video output, to an external video signal.

18. IRIG input: An IRIG-B decoder is built in to the camera to allow for the time stamping of each frame.

ACCESSORIES

We offer a wide range of accessories from HD tripods to Pan & Tilt systems. Most cameras we supply are built to your bespoke requirements and we'll provide advice on the most suitable hardware to suit your system.

X-Series Filter Wheels

- ND 1.0
- ND 2.0
- ND 3.0
- ID07 MWIR - Standard MWIR, 3.0 - 5.0 μm, MWIR imaging
- ID10 Thru Glass - Inspections through glass
- ID11 Glass Surface - Makes glass suface opaque
- ID12 Flame - Inspections through flame
- ID15 Plastic - Makes some thin film plastics opaque
- ID16 CO_2 - Imaging CO_2 band
- ID17 Nitrous-Oxide - Imaging CO_2 band
- ID18 COS - Flame imaging
- ID23 Thru Glass HT
- ID24 Glass Surface HT
- ID25 Flame Surface HT

X-Series Filter Wheels Blank Filter Holder

- X-Series Filter Wheel Blank Filter Holder
  (XX = 40-58 filter IDs reserved for custom cal and camera recognition)
  (X69XX, X68XX, X85XX)

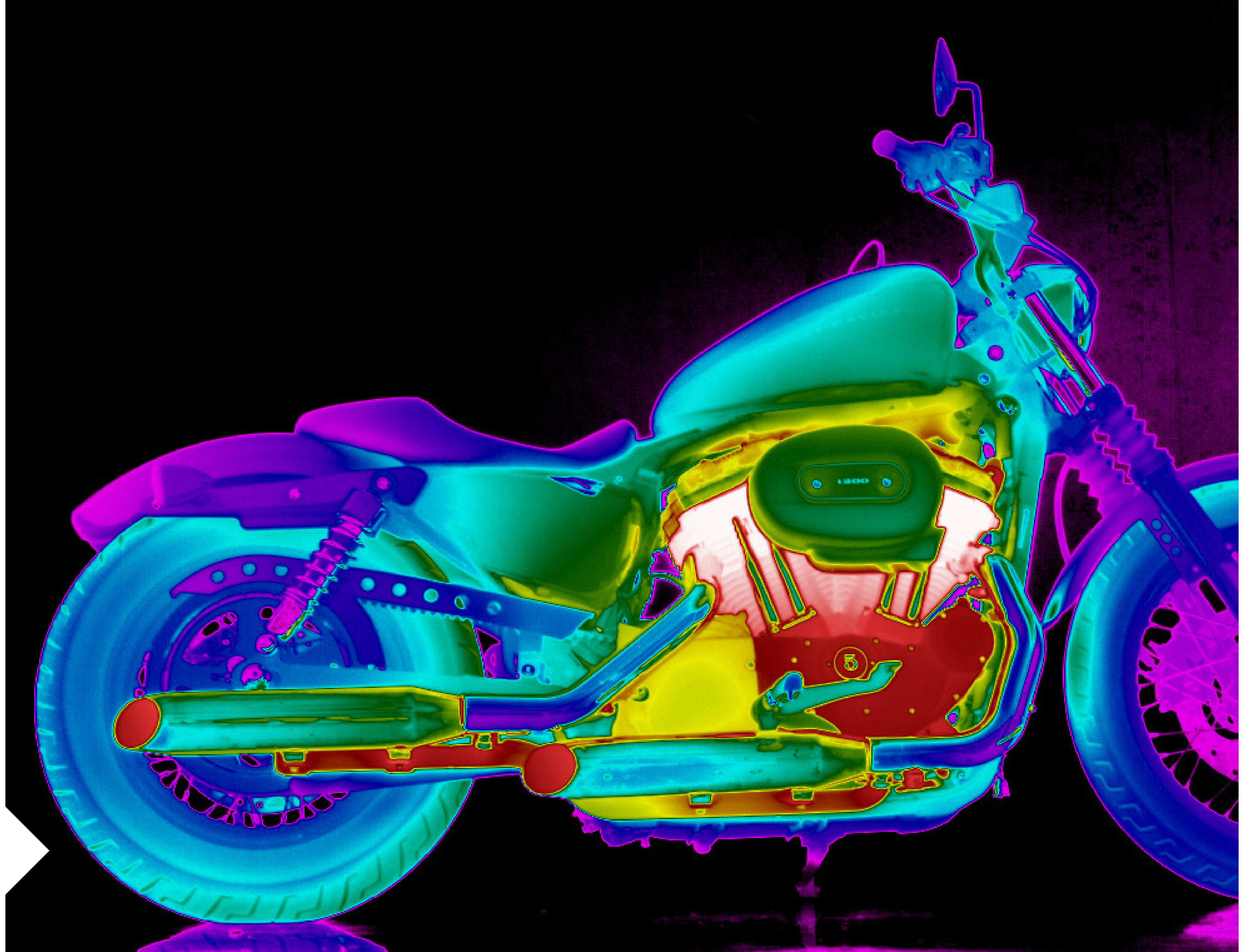
Pan & Tilt system

Data logger

Custom housings

HD tripod

IMAGE TAKEN WITH: FLIR - 1344 X 784 - COOLED - I NSB - 14UM - PITCH - SC8300



Using thermal imaging technology

OVERVIEW: FLIR A6700sc Series

Detector Type
FLIR Indium Antimonide (InSb)

Dynamic Range
14-bit

Accuracy
±2°C or ±2% of reading

NETD
<18 mK

Spectral Range
3.0 – 5.0 μm or 1.0 – 5.0 μm

Size [L x W x H] without Lens
216mm x 102mm x 109mm
(8.5" x 4.0" x 4.3")

Weight (without Lens)
2.3 kg (5 lbs)

USING THERMAL IMAGING TECHNOLOGY

FLIR's **world-leading** R&D camera range combines high performance thermal imaging and precise temperature measurement, with **powerful tools** and **software** for **analysing** and **reporting**.

Their cameras can distinguish temperature changes as subtle as 0.02°C, provide precise measurements from -80°C to +3000°C, and feature state-of-the-art detector technology. These are just some of the reasons why FLIR is typically the first choice for R&D professionals.

Research & Development

Thermal imaging has proven itself to be an indispensable analysis method in the R&D community – its application possibilities are seemingly endless.

Printed circuit boards

Understanding heat dissipation within a circuit board is extremely difficult, but thermal imaging makes this possible without compromising performance.

Thermal imaging microscopy

When a thermal imaging camera is combined with a microscope, it becomes a thermal imaging microscope. Using this technology, temperature measurements can be taken from subjects as small as 3microns.

Medical thermography

FLIR cameras are widely used in medicine diagnostics and treatment. They provide an accurate, measurable, non-contact technique which can capture changes in surface temperatures.

High-speed/stop motion

With cameras capable of microsecond exposure times capturing more than 62,000 frames per second, FLIR is at the cutting edge of high-speed camera technology. Its pioneering applications of high-speed thermography include analysis of jet engine turbine blades, supersonic projectiles and explosions.

Thermal signatures

Commonly used in the design of vehicles, sensors and camouflage systems, thermal signatures measure infrared brightness and can reveal the appearance of a given object.

Tracking

Thermal imaging camera systems can be used to work alongside video tracking systems to help maintain visibility and track a specific object when working in low light conditions.

Directed energy

Directed Energy Weapons (DEW) include laser, high power radio frequency and particle beam technologies. Thermal imaging cameras are used in the testing of DEW instrumentation and the analysis of target impacts.

Laser designation

Laser designators emit a beam of laser energy which is used to mark a specific place or object. Thermal imaging cameras can detect these otherwise invisible laser beams and are used for identifying locations and targets.

Infrared Non-Destructive Testing (IR NDT)

IR NDT can identify internal issues by studying thermal differences on a target surface. It's a valuable tool for detecting voids, delaminations and trapped water in composite materials.

Technical surveillance and countermeasures

Thermal imaging is used to identify heat signatures from covert surveillance devices. Even devices hidden within objects can be revealed by the minute energy given off in the form of IR energy.

Short Wave Infrared (SWIR)

This is used in the non-destructive quantitative analysis of crops, pharmaceuticals and agricultural products. It's also used to examine art forgeries.

CASE STUDY #1
IN PRACTICE: Road repair

Tens of thousands of bridges across the United States have been in use long past their 50-year design life, meaning there's a $multi-billion repair and maintenance job to be done. The challenge however lies in identifying which sections of road have become delaminated and are in need of repair.

Using traditional methods, inspectors apply a non-destructive testing process called acoustic chain dragging. The chain makes a distinctive hollow sound when it's dragged across a delaminated section of road, which an inspector then manually logs. This method is time consuming, subjective, can be compromised by other road noises and requires lane closures.

NEXCO-West USA wanted to find a high tech alternative to this method and started to work with FLIR's A6701sc camera. Mounted on a truck to pinpoint delaminated sections of road, this NDT inspection technique incorporated images from a cooled FLIR infrared camera, into maps created with NEXCO-West's own software.

Inspections were carried out with the truck-mounted infrared camera while driving across a bridge at 50 miles per hour, with traffic, during the day or within a few hours after sunset when large temperature shifts can be seen. Roads normally heat and cool evenly, but delamination interrupts the conduction path, so could be easily detected by the IR camera. The camera was set for a 10Hz frame rate which records a crisp, thermal image every two metres and accurate data for a mile-long bridge can be gathered in just a few minutes. The camera was connected to a laptop inside the vehicle so the team could see real-time analysis and could identify potentially delaminated areas.

This high-tech approach has proven so successful that NEXCO-West engineers are now working with others to develop efficient inspection procedures which could be used by state highways agencies across the US.

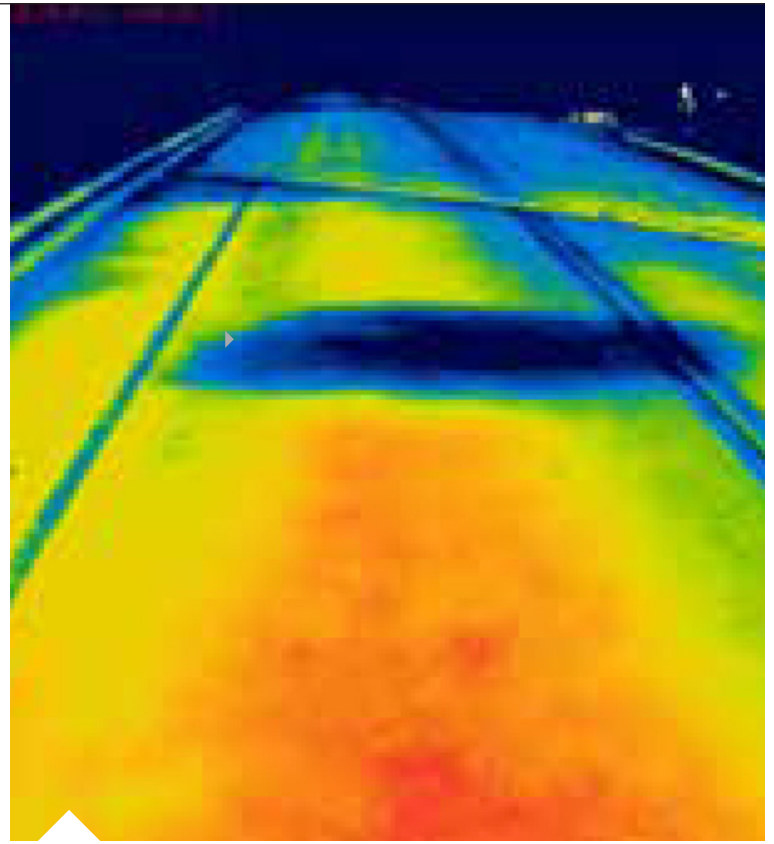


IMAGE: Thermal image used to create bridge deck deficiency map

CASE STUDY #2
IN PRACTICE: Pilot performance

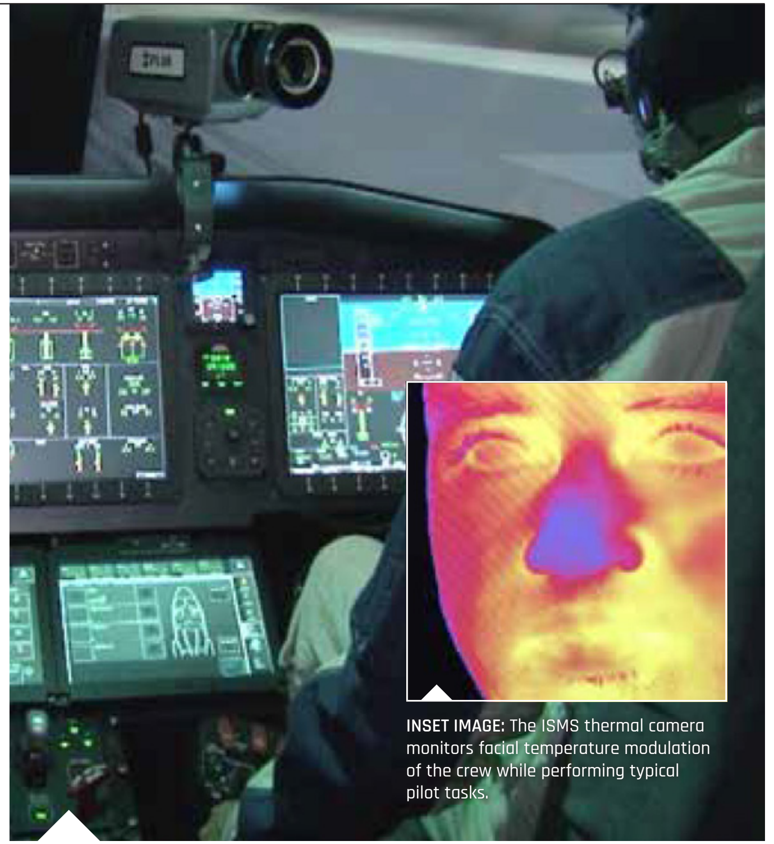
Helicopter pilots are under immense pressure in the cockpit. With information being passed to them simultaneously from internal and external sources, manufacturers and training providers need to ensure the pilot's environment allows them to remain calm and able to do their job.

Italian helicopter manufacturer Leonardo wanted to find a reliable and objective way to measure the stress that pilots experience, to help them design more functional cockpits and deliver effective training.

Leonardo teamed up with NexT2U, a scientific start-up company, and the Italian Army Aviation to develop an Infrared Stress Monitoring System (ISMS). Cold sweat or feeling warm are both indicators of stress and affect skin temperature, so the non-invasive stress analysis system included the FLIR A6750sc - a cooled camera capable of capturing the subtle changes in skin temperature associated with human emotions.

The FLIR A6750sc was also the ideal camera to choose for this experiment as it complied with the strict technical constraints for flight simulators – having suitable performance, dimensions and weight for example. It can also freeze motion and perform accurate temperature measurements on moving subjects and its high resolution of 640-x512 provides a good definition of the morphological features of the face of the pilot.

When combined with the data captured from other sources as part of the ISMS, Next2U has commented on how thermal IR imaging has matured to now provide an insight into how humans interact with machines.



INSET IMAGE: The ISMS thermal camera monitors facial temperature modulation of the crew while performing typical pilot tasks.

MAIN IMAGE: The ISMS helps Leonardo understand stress imposed on pilots during missions, either in simulators or in real missions.

CASE STUDY #3
IN PRACTICE: Photonics research

As demands on consumer technology increase, so too do the challenges for equipment manufacturers to find new ways of integrating devices to support the next generation's communication needs.

The level of integration required brings with it a challenge for thermal management however. As more and more functionality is needed to be built into less packing space, it becomes more likely the photonic platform will overheat.

To manage this problem, researchers at the Tyndall National Institute in Cork, Ireland are developing a passive optical network (PON) for high-speed fibre-to-home internet connectivity. They're using a silicon photonic integrated circuit (Si-PIC) to receive incoming information (downloading), before reflecting an optical signal back (uploading). Within this device they're bonding an electronic integrated circuit (EIC) to manage the electronic timing signals which are needed to drive an optical modulator. However, these high-frequency timing signals cause an increase in temperature, which can have an impact on how the photonic chip works.

Researchers used the FLIR X6540sc – a high speed, full frame (640 x 512) camera to simultaneously measure the temperatures of the EIC and Si-PIC, to find the most efficient way to thermally stabilise the photonic chip. As a result, they have been able to see thermal activity in much greater detail than ever before and have seen how the thermal management of the photonic module accounts for around 30% of the overall power budget.

They plan to use the camera as part of their ongoing development of packaging design – refining photonic platforms to meet future technology needs.

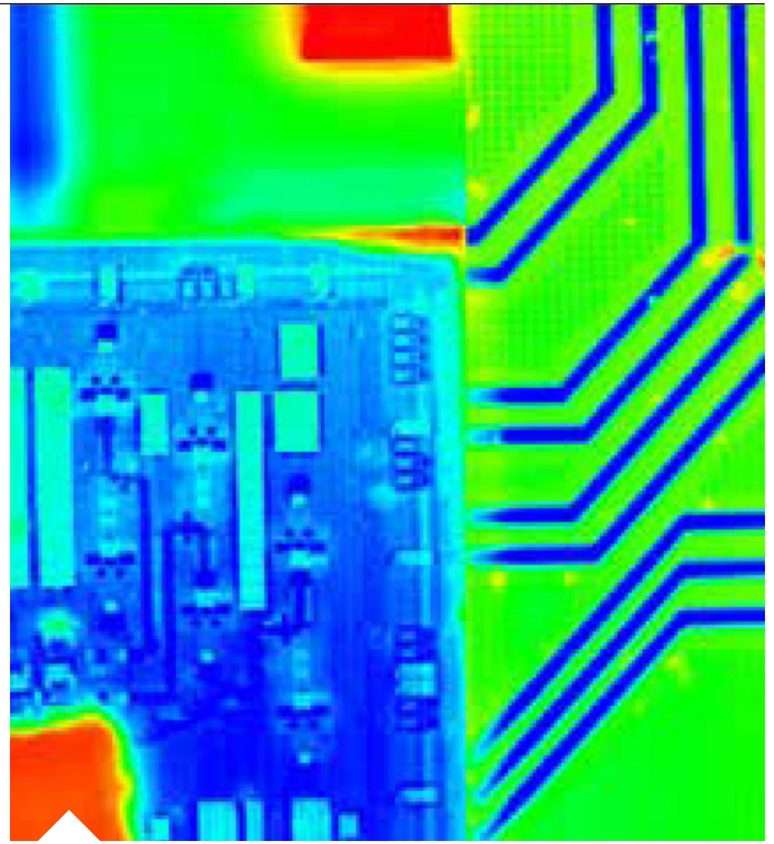


IMAGE: Measurement of EIC and Si-PIC temperatures on a Si Photonic Chip (composite thermal image).

CASE STUDY #4
IN PRACTICE: The electrocaloric effect

The fridge in your kitchen uses a coolant that turns into a gas. This process works, but it can be harmful to the environment.

At the Luxembourg Institute of Science & Technology (LIST), researchers are using FLIR thermal imaging cameras to see how solid materials which exhibit the electrocaloric effect, could be used instead to cool down food, drinks and medicine.

The electrocaloric effect is a phenomenon whereby a polarisable material can have a reversible change in temperature when an electric field is either applied or taken away. A fridge could be cooled by this method for example, by increasing the frequency of the electric field applied to an object, followed by a rapid heat exchange with its surrounding environment.

The rate of heat exchange is crucial to success, so LIST scientists needed to determine how this process might be limited by the material used – in terms of its thermal conductivity, or by its shape, for example. Indirect measurement methods had previously been used, but the results were not always accurate. But when the team started using the FLIR X6580sc, they were able to gain accurate and sensitive imaging data of caloric effects and thermal behaviour of the different materials, both temporally and spatially.

LIST combined the FLIR X6850sc with a lens which enabled them to achieve a 3x magnification – capable of capturing very small temperature differences at a very high frequency. The team then combined this with FLIR's ResearchIR Max software for thermal measurement, recording and real-time analysis. The software allowed them to record temperature changes induced by the electric field and make better distinctions in the image between what was induced by the electric field and what was image noise. Overall, they were able to review the thermal images in a higher level of detail than before and generate positive results for their ongoing research.

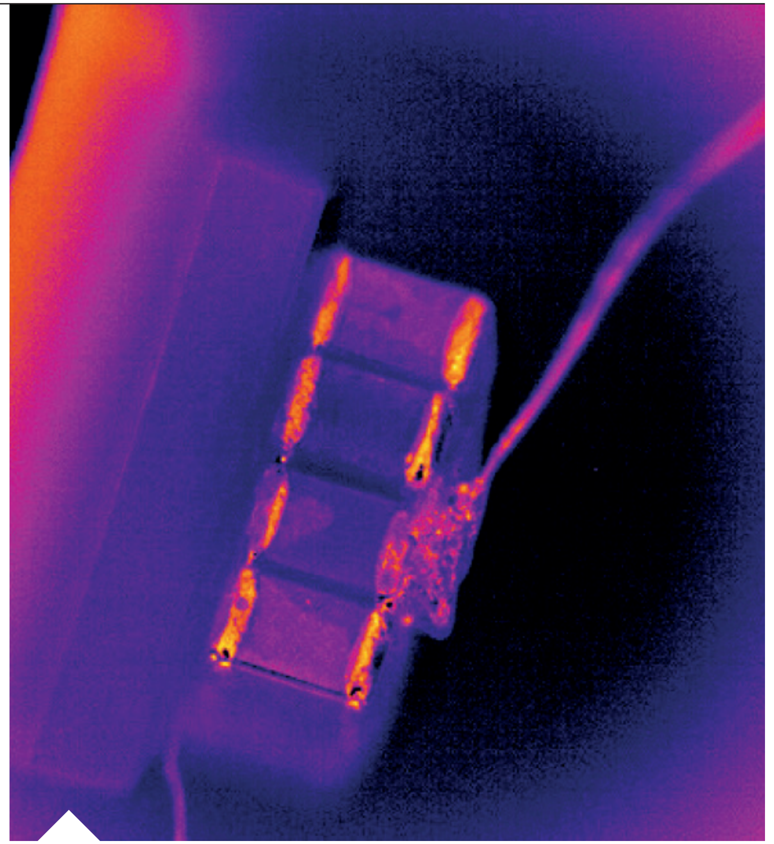


IMAGE: The electrocaloric effect in thin films could have the potential to be used for efficient refrigerators and cooling systems for high power electronic devices.

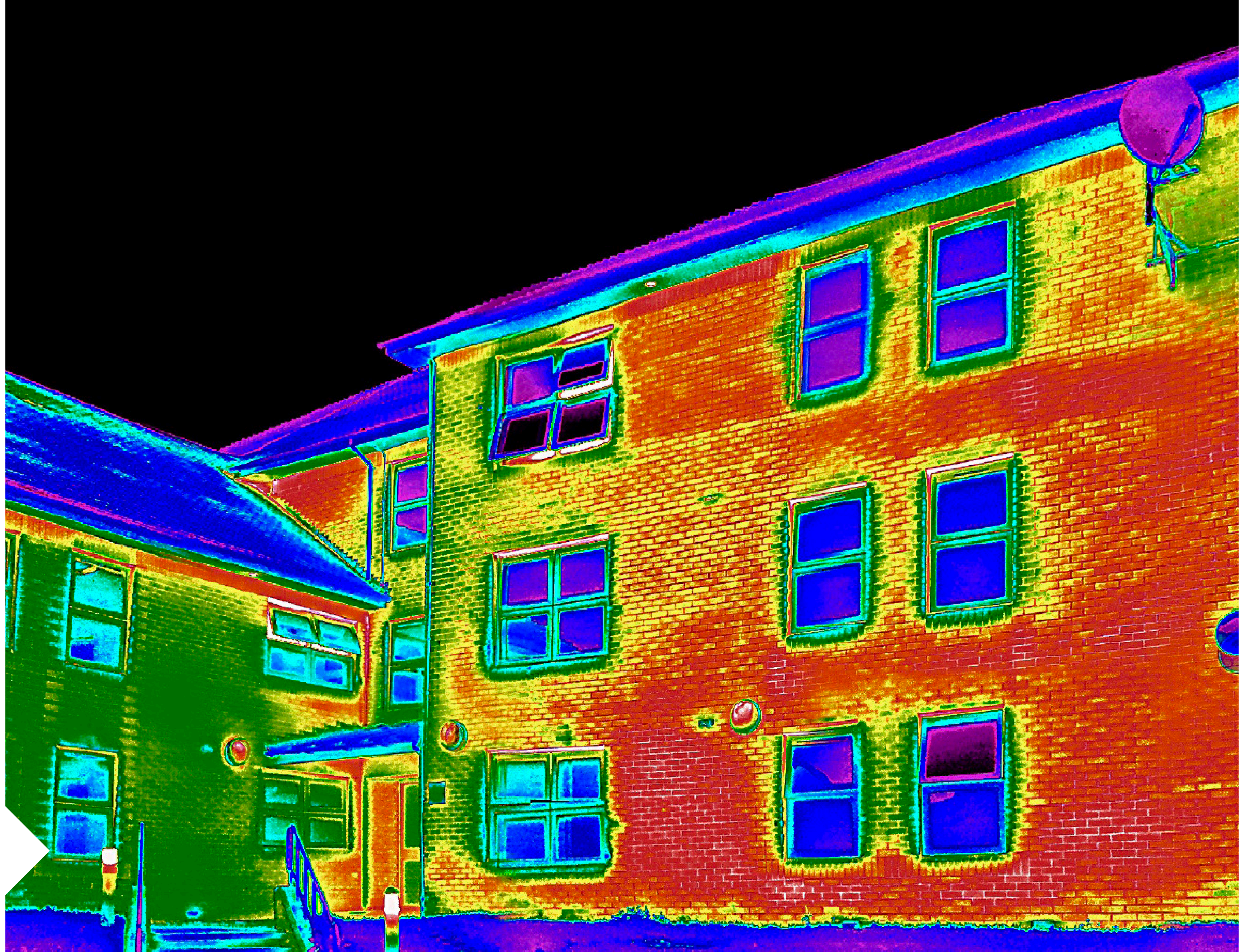


IMAGE TAKEN WITH: FLIR T1020 - THERMAL CAMERA 1024 X 768 RESOLUTION

Cameras and software

Cameras

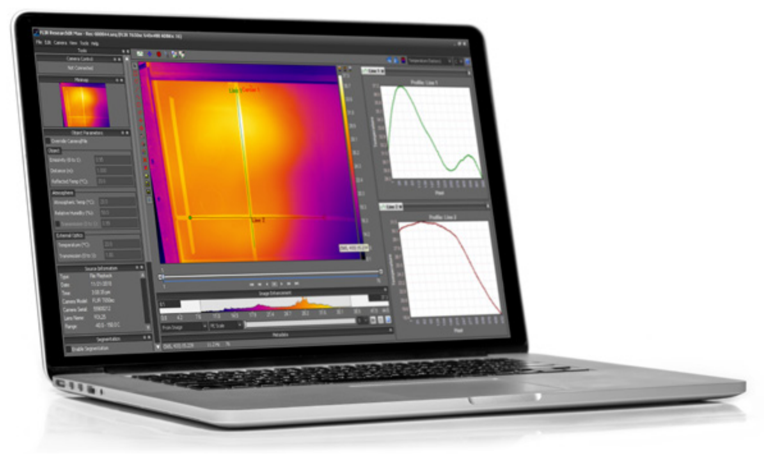
FLIR's R&D/Science infrared camera solutions offer the sensitivity, spatial resolution, frame speed and integration time needed to capture fast temperature changes, and take pinpoint accurate temperature readings on targets with motion.

	PERFORMANCE LEVEL CAMERAS		ADVANCED LEVEL CAMERAS		
SPECIFICATIONS	**A6260sc**	**A6700sc Series**	**X6800sc Series**	**X6900sc Series**	**X8500sc Series**
	Ideal for high temperature measurement through glass, astronomy, laser profiling, medical research, solar cell inspection, or any application that can benefit from a 640 x 512, high sensitivity SWIR camera.	Deliver sensitivity, accuracy, and resolution in an affordable package. Fast MWIR InSb or LWIR SLS sensors offer stop-motion imagery of dynamic events for reliable temperature measurement.	Designed to maximise speed and sensitivity, X6800s series cameras detect temperature differences of <20 mK and offer Camera Link, Gigabit Ethernet, and other connectivity options.	The X6900sc is the world's fastest full-sensor thermal infrared camera on the market. With 1004 fps, it is ideal for highly dynamic and high speed applications.	Offering 1280 x 1024 HD resolution at fast frame rates of 181 fps, the X8500sc offers a perfect blend of high definition and high speed for those most demanding R&D/ Science and test range applications.
Lens Options	16 mm, 25 mm, 35 mm, 50 mm, 100 mm	3-5 µm: 17 mm, 25 mm, 50 mm, 100 mm, 200 mm Broadband (1.5-5 µm): 25 mm, 50 mm, 100 mm (Uses FLIR HDC Optics)	3-5 µm: 17 mm, 25 mm, 50 mm, 100 mm, 200 mm Broadband (1.5-5 µm): 25 mm, 50 mm, 100 mm (Uses FLIR HDC Optics)	3-5 µm: 17 mm, 25 mm, 50 mm, 100 mm, 200 mm Broadband (1.5-5 µm): 25 mm, 50 mm, 100 mm (Uses FLIR HDC Optics)	3-5 µm: 17 mm, 25 mm, 50 mm, 100 mm, 200 mm Broadband (1.5-5 µm): 25 mm, 50 mm, 100 mm (Uses FLIR HDC Optics)
Waveband	SWIR	MWIR, LWIR	MWIR	MWIR	MWIR
Sensor Type	InGaAs	InSb / SLS	InSb	InSb	InSb
Pixel Resolution	640 × 512	640 × 512	640 x 512	640 x 512	1280 x 1024
Detector Pitch	15 µm	15 µm	25 µm	25 µm	12 µm
Spectral Range	0.6 – 1.7 µm, 0.9 – 1.7 µm	1.0 – 5.0 µm, 3.0 – 5.0 µm (InSb) 7.5 – 10.5 µm (SLS)	1.5 – 5.0 µm, 3.0 – 5.0 µm	1.5 – 5.0 µm, 3.0 – 5.0 µm	1.5 – 5.0 µm, 3.0 – 5.0 µm
NETD		<20 mK (InSb), <35 mK (SLS)	<20 mK	<20 mK	<20 mK
NEI (Low Gain, High Gain)	Low Gain: 8.35E9 ph/sec/cm2 Medium Gain: 2.89E9 ph/sec/cm2				
Dynamic Range	14-bit	14-bit	14-bit	14-bit	14-bit
Accuracy	±2°C or ±2% of reading	±2°C or ±2% of reading	±2°C or ±2% of reading	±2°C or ±2% of reading	±2°C or ±2% of reading
Min Integration/ Time Constant	0.48 µs	480 ns	480 ns	480 ns	480 ns
Camera Temp Calibration	Optional	X	X	X	X
Standard Camera Calibration Range		-20°C to 350°C (InSb), -20°C to 650°C (SLS)	-20°C to 350°C	-20°C to 350°C	-20°C to 350°C
Optional Camera Calibration Range	400°C up to 3000°C	Up to 3,000°C	Up to 3,000°C	Up to 3,000°C	Up to 3,000°C
Ambient Drift Compensation		X	X	X	X
Digital Full Frame Rate	125 Hz	A6700sc - 60 Hz / A6750sc - 125 Hz	502 Hz	1004 Hz	181 Hz
Digital Data Streaming	Gigabit Ethernet	Gigabit Ethernet	Simultaneous Gigabit Ethernet and Camera Link	Simultaneous Gigabit Ethernet, Camera Link, and CoaXPress	Simultaneous Gigabit Ethernet, Camera Link, and CoaXPress
Analog Video	Composite	Composite	HDMI	HDMI, HD-SDI, Composite	HDMI, HD-SDI, Composite
Camera Control	Gigabit Ethernet	Gigabit Ethernet	Gigabit Ethernet, USB, RS-232, and Camera Link	Gigabit Ethernet, USB, RS-232, Camera Link, and CoaXPress	Gigabit Ethernet, USB, RS-232, Camera Link, and CoaXPress
FPA Windowing	User-Defined	User-Defined	User-Defined	User-Defined	User-Defined
Manual Tactile Focus	X	X	X	X	X
Motorized Focus					
Auto Focus					
Built-in IRIG-B Timing	Optional		Optional	X	X
Triggering Options	Trigger & Sync I/O	Trigger & Sync I/O	Trigger & Sync I/O	Trigger & Sync I/O	Trigger & Sync I/O
Integrated Visual Camera					
Integrated GPS					
On-Camera Image Storage			Up to 52 sec full frame rates to RAM - 1 TB SSD for storage	Up to 26 sec full frame rates to RAM 1 TB SSD for storage	Up to 36 sec full frame rates to RAM 1 TB SSD for storage
Developer Tools	GigE Vision, SDK	GigE Vision, SDK	GigE Vision, SDK	GigE Vision, SDK	GigE Vision, SDK
F/number	Lens-Dependent	f/2.5, f/4.0	f/2.5, f/4.1	f/2.5, f/4.1	f/2.5, f/4.1
Filtering Options	Single Behind-the-Lens	Single Behind-the-Lens	Single Behind-the-Lens & Motorised 4-Position Filter Wheel with Auto Filter Recognition	Single Behind-the-Lens & Motorised 4-Position Filter Wheel with Auto Filter Recognition	Single Behind-the-Lens & Motorised 4-Position Filter Wheel with Auto Filter Recognition

Software

Once we've helped you make your camera selection, you need a compatible software package to ensure you can capture the best possible data to then analyse and share your findings.

FLIR offers a specialist software product called FLIR ResearchIR Max. It provides camera control, high-speed data recording, image analysis and data sharing, specifically for research and science.



Here's how it works:

FLIR ResearchIR Max

Aquisition
ResearchIR Max software connects directly to FLIR research and science cameras via USB, Gigabit Ethernet or Camera Link to gather thermal snapshots or movie files. You can easily tailor how your data is recorded, including how many frames you want to capture.

Analysis
ResearchIR Max uses an extensive range of measurement tools to carry out real-time image analysis. The software also includes a selection of reporting options, depending on what and how you want to communicate your findings.

Share
Data gathered in ResearchIR Max can be saved as Bitmap or CSV files for use elsewhere – and data frames can even be exported to third party analysis software as a CSV, 320-bit, TIFF or a MatLab® file.

Other options

FLIR cameras are also compatible with other software platforms, which you can tailor to your own unique requirements.

Genicam
GenicamTM is the global standard for the computer control of digital cameras and other imaging products. It allows the industry to use the same interface to programme applications for any compliant camera or imaging transmission product. It has three modules to help with solving the main tasks in machine vision field: GenApi; Standard Feature Naming Convention; and GenTL. And it provides support for five basic functions: Configuring the camera; Grabbing images; Graphical user interface, transmitting extra data; and Delivering events.

BHP SDK
Provided by FLIR to allow end users to create bespoke packages. FLIR Research MAX was created using BHP SDK.

FLIR's BHP SDK allows users to integrate camera control and GigE data streaming into their own applications. The BHP SDK provides C/C++ functions to control all available camera operations – and the SDK, is a visual studio project with sample programs to demonstrate how to use the various functions.

GigE
Gigabit Ethernet is a common interface found in most PCs. It can be used for image acquisition and/or camera control and is GEV/Genicam compliant.

As a tailored, specialist software package FLIR ResearchIR Max also offers a whole range of additional features:

Emissivity calculator
Using the built-in Emissivity Calculator, emissivity values can be manually adjusted.

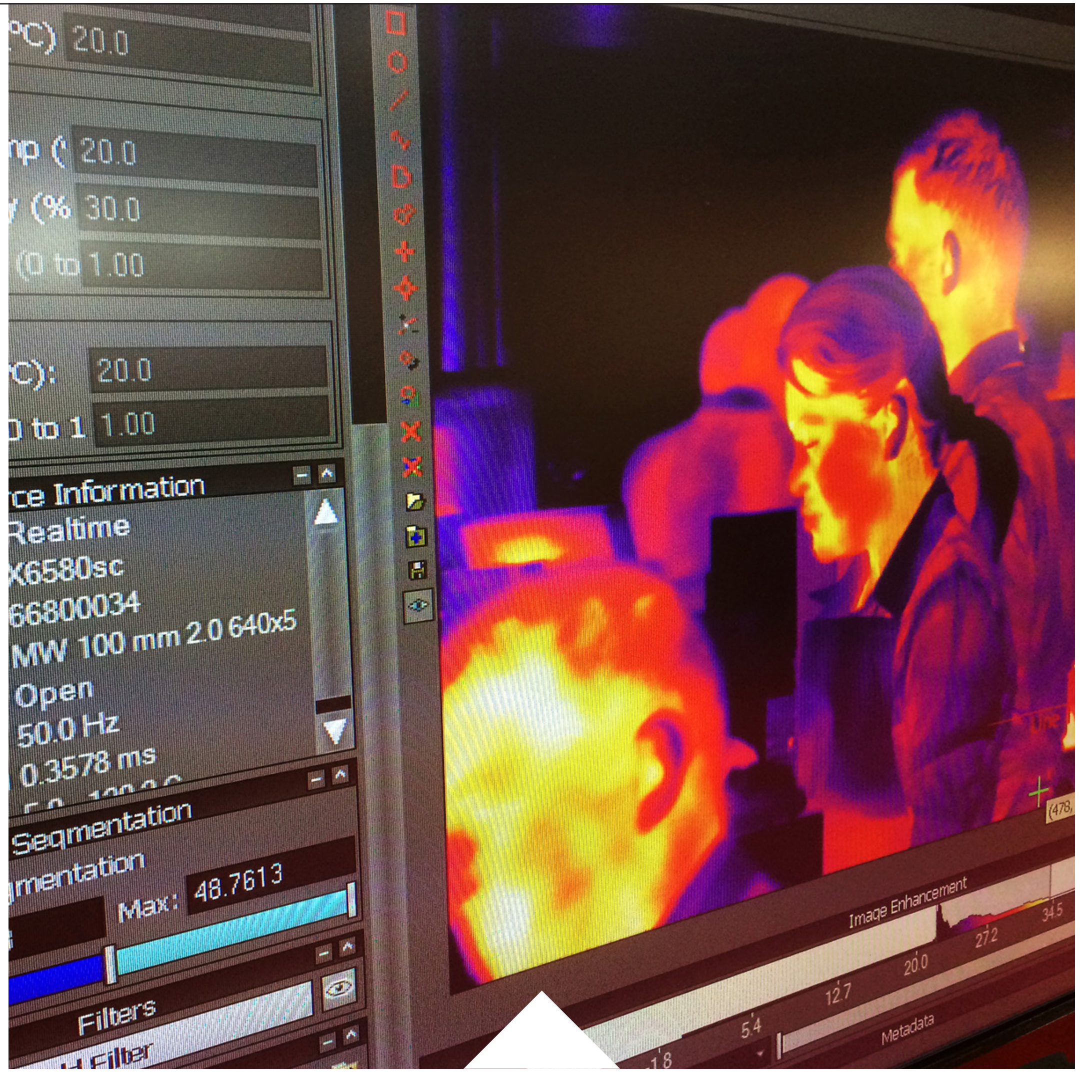
Spatial calibrations
Measurements gathered by the camera can be calibrated to standard units of area and length.

Custom thermographic and radiometric calibrations
A step-by-step guide helps you tailor the software to suit your own needs.

Measurement function editor
Measurement analysis can be customised and graphically presented.

Self-viewing files
With self-viewing files you can share your thermal images, movies and data with others who don't own a ResearchIR Max licence.

MathWorks® MatLab compatible
ResearchIR Max can access MatLAb scripts directly for tailored image analysis and processing.



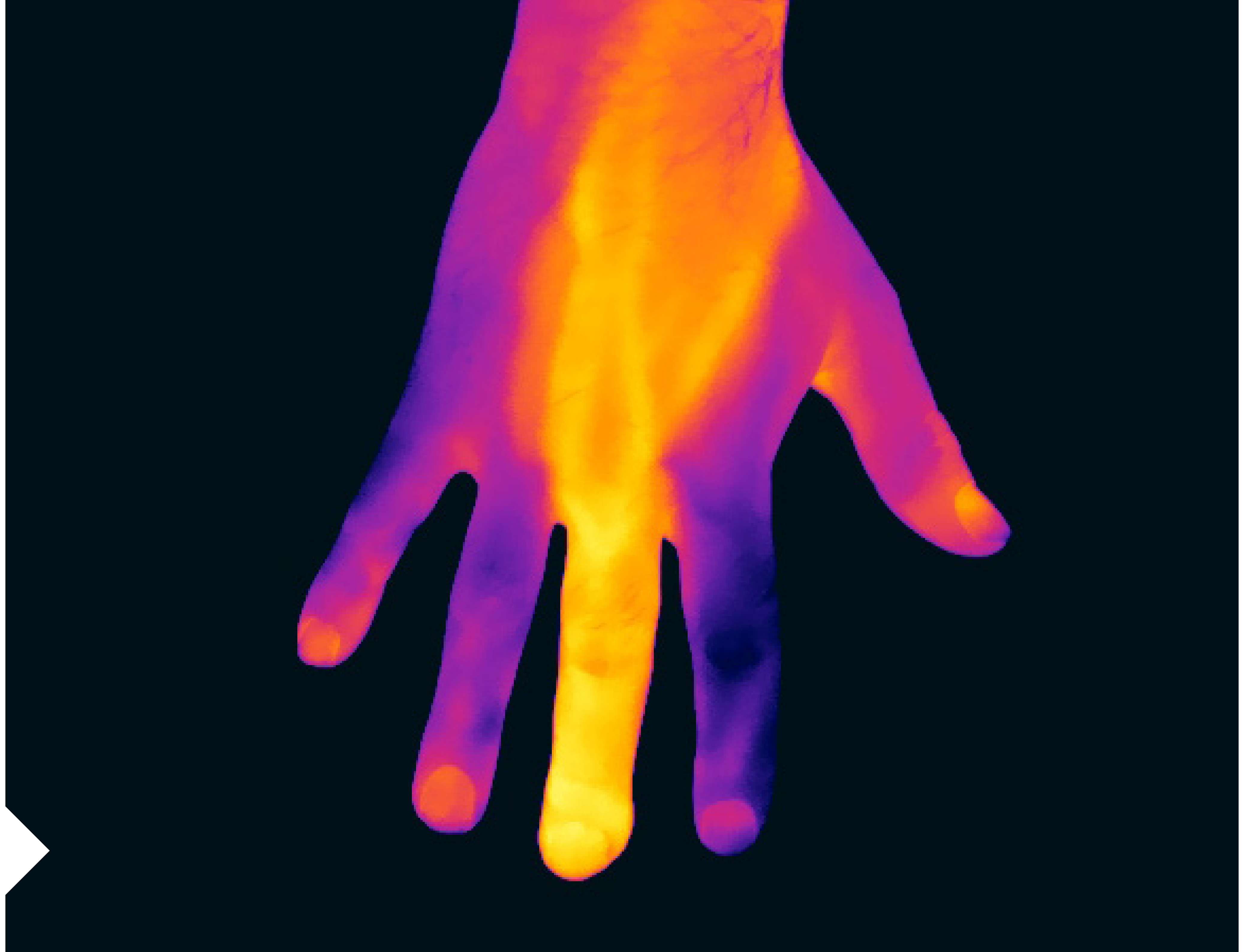


IMAGE TAKEN WITH: FLIR T650SC - THERMAL CAMERA 640 X 480 RESOLUTION

Service & Support

We understand your FLIR camera is essential for your work. And, in the same way you couldn't work without your laptop or phone, if you have an issue with your camera, you need it back up and running as quickly as possible.

Prevention is always better than cure which is why FLIR recommends investing in one of its tailored maintenance packages. These include a 14-point inspection and calibration programme:

1. A complete operational check
2. Calibration of MSX and laser alignment
3. Checking of all internal cables and PCB connections
4. Cleaning the viewfinder and checking the optics
5. Upgrading internal camera software with the latest versions
6. Performing minor repairs
7. Verifying/re-equalising the temperature ranges
8. Verifying the standard lens calibration
9. Verifying the ambient temperature compensation
10. Recalibrating the camera to meet factory specifications
11. Calibrating temperature ranges up to 1,500°C if appropriate
12. Performing quality-approved acceptance test procedures
13. Providing calibration labelling with the next maintenance date
14. Providing a calibration certificate

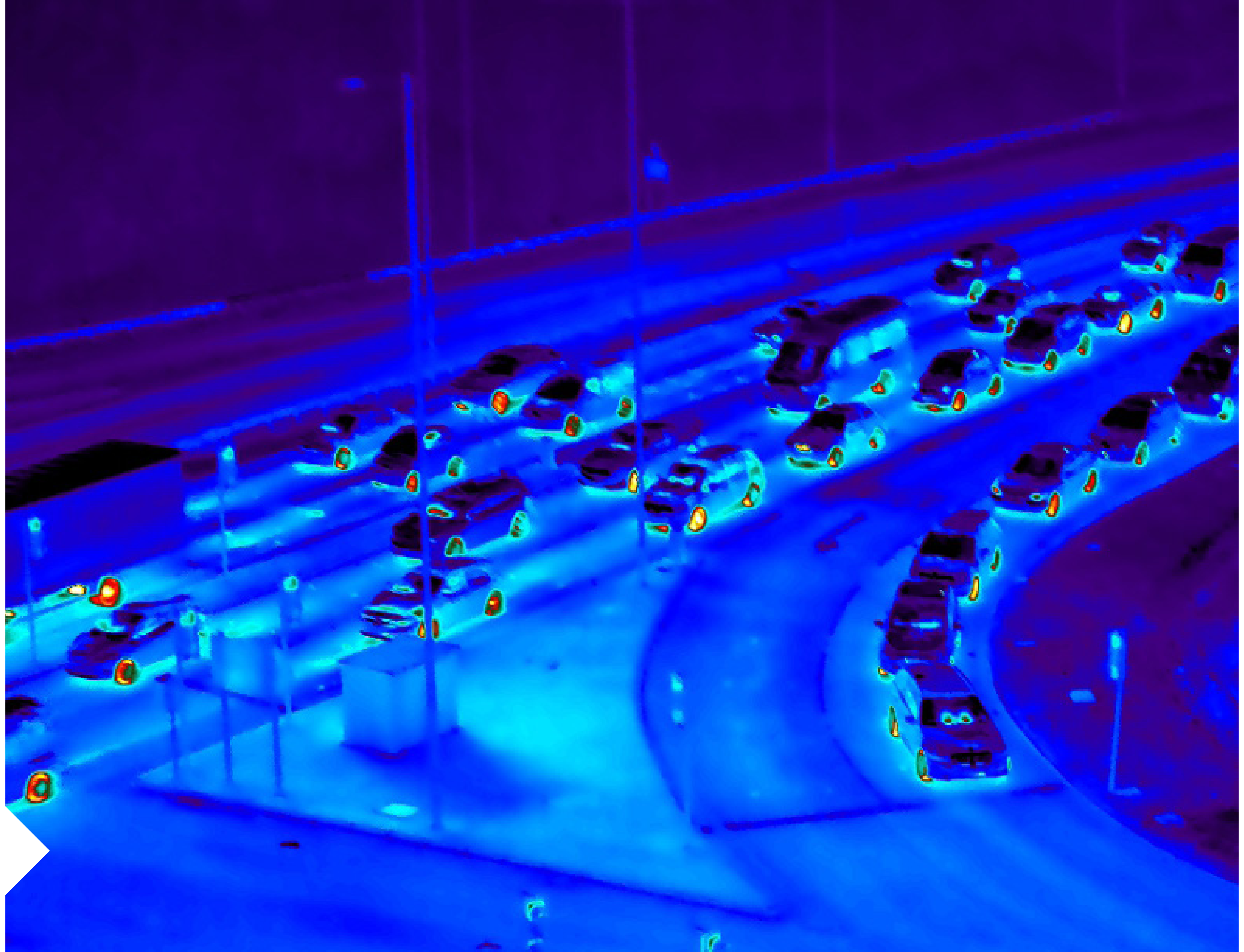


IMAGE TAKEN WITH: FLIR T650SC - THERMAL CAMERA 640 X 480 RESOLUTION

WHO WE WORK WITH

Thermal Vision Research has amassed many years of experience in the capabilities of the ever-changing portfolio of FLIR infrared cameras as they are used in the research and scientific markets. By accessing this, we are able to quickly specify the instrumentation and support packages our projects need and know there is knowledgeable back up available.

Cailean Forrester
Managing Director
Inspectahire

We consider TVR a valuable partner to our research. We acknowledge that without Matthew's repeated visits to the University and his valuable comments, suggestions and constructive criticism, we wouldn't have obtained the quality data needed for our research.

John Karadelis
Senior Lecturer in Computational Mechanics
Coventry University

Matthew has worked with us over the past six years to address a number of thermal imaging requirements for various applications spanning R&D as well as designing thermal imaging technology into custom products. His familiarity with the FLIR product range and experience of applying thermal imaging techniques in a research and development environment has been invaluable in helping us select the best suited products to meet our requirements. The on-site demonstrations and short term rentals have also given us absolute confidence, that we've selected both the right product and the right supplier. We thoroughly value Matthew's expertise and focus on problem solving rather than box shifting. I would highly recommend others to seek out his services for any thermal imaging applications.

Chris Deighton
Engineering Manager
Carillon Ltd

PEPSICO
JAGUAR LAND ROVER
3M
dyson
Panasonic
BBC
Unilever
Ministry of Defence
nationalgrid
P&G
ROLLS ROYCE
Brunel University London

FLIR AUTHORISED SCIENCE PARTNER

CONTACT US

Thermal Vision Research Team

0333 200 4667

info@thermalvisionresearch.co.uk

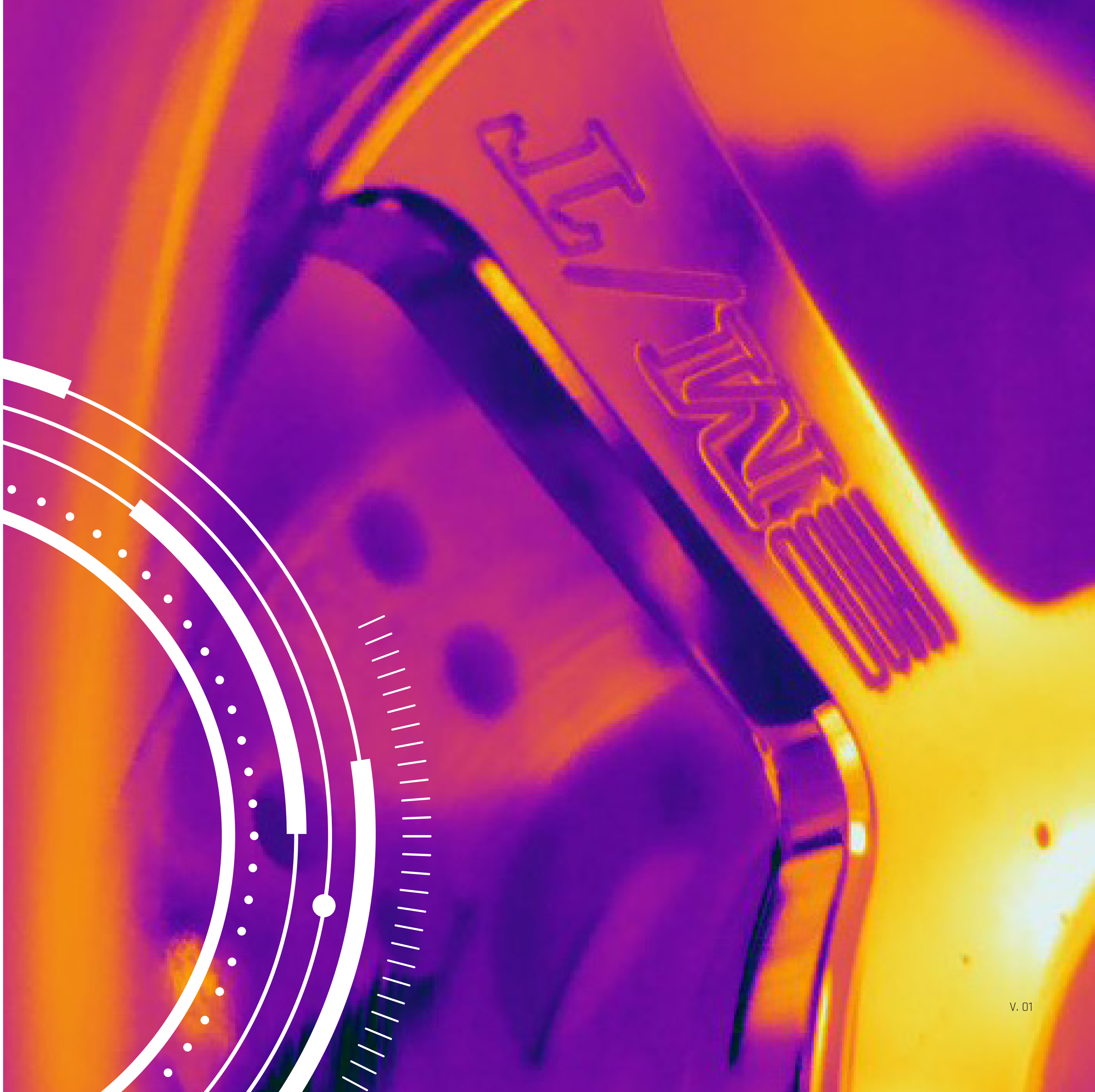
www.thermalvisionresearch.co.uk

@thermalvision

thermalvisionresearch

Matthew Clavey

Thermal Vision *Research*



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