TECHNOLOGY FOR MOTORSPORT

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Racecar engineering

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Hot shots

With thermal imaging cameras now affordable, could they proclaim a breakthrough in understanding how a racecar performs? **Racecar** puts one to the test to find out

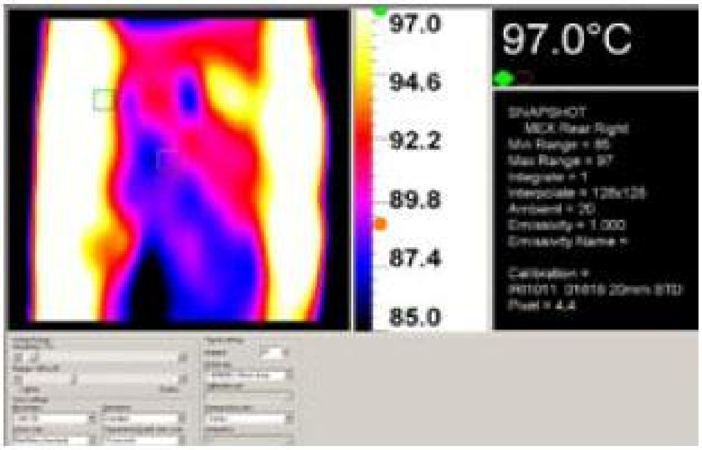
Words	Sam Collins
Images	Collins; Woodvine

Andy Woodvine demonstrating the thermal imager at Silverstone above, taking readings from the A1 Team France Car

How many tire temperatures should you take per tire? The man from RML said three across the tire – 'outside edge, middle and inside edge.' Would any more tire temperature information help, asked Racecar? 'It's not relevant because you simply can't get around to all four tires and get any more than three good readings before the tires have cooled.' That is the perceived wisdom and little has changed until now.

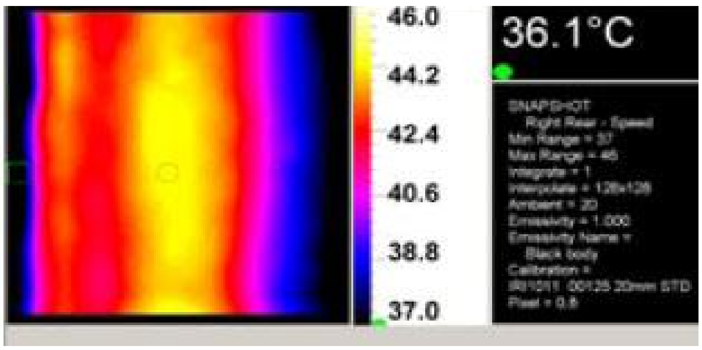
The Wahl low-cost thermal imager can allow teams to record tire temperatures in seconds, without scrambling around all four corners to record 12 temperatures spots. A real time reading can be taken over the entire tire, but with the ability to store that thermal image in memory, as many as 10 spot temperatures that can be displayed at once, later on a laptop. What this allows is for the pit crew to read the temperatures stored on the picture (all 10 of the temperature points can be moved around anywhere on the picture) to determine tire loads and contacts, allowing them to more accurately plan for chassis adjustments for the next pit stop.

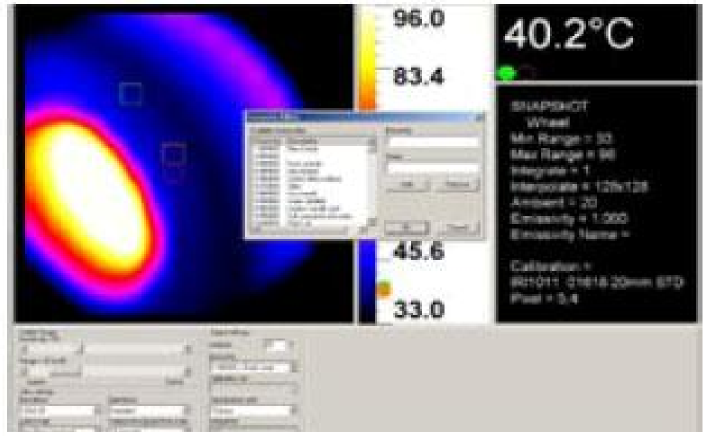
The usefulness of this technology was illustrated during a recent club race meeting at Silverstone, in England, where a Speads single seater showed a strange cold spot on its right rear tire – chances are a pyrometer could easily have missed it. Other trials were conducted during the day on a variety of racecars and objects hot and cold, including a shot of



Right rear tire of A1 Team Mexico's Lola just after removal of tire blankets. Uneven heating is clearly evident, with nearly 10 degrees of fluctuation. Particularly of note are the hot and cold spots left on the tire.

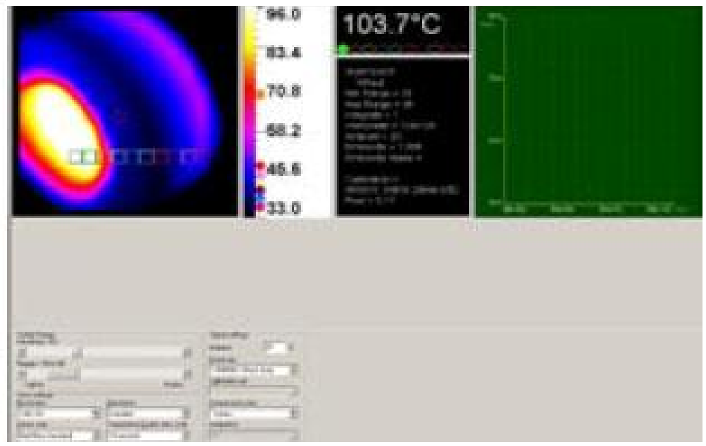
Right rear tire of a Spreads RM05 taken in Parc Femma after a 10—lap club race on Silverstones National circuit. Note the cool stripe on the left running the entire circumference of the tire. Although it was only a two-degree difference it could point to a number of problems, including a tire defect. Interference from the engine and exhaust is unlikely as the problem did not occur on two other identical cars racing at the same event.





Getting the right Emissivity value for a surface is the key to obtaining an accurate reading. The Wahl thermal Imager comes with a number of present values but currently none specifically for motor sport applications.

Taking 10 temperatures across a tire is easy with the thermal imager. But tire spot temperatures are redundant with an overall visual image.



the engine bay of Rod Birley's Ford Escort WRC taken immediately after a race which revealed the turbocharger was over 100 degrees hotter (325degC) than anything else around it. Even inadequately heated cups of tea were captured, but more serious tests were required.

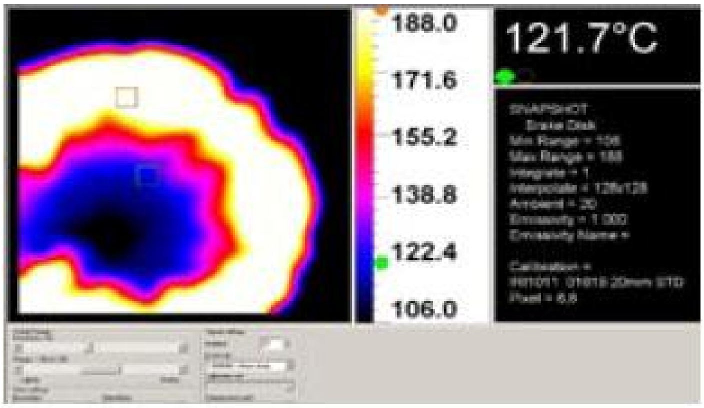
French outfit Driot Associates Motor Sport (DAMS) offered to try the technology on the tires and brakes of it's GP2 and A1GP Cars, offering a direct comparison with the usual probe-type pyrometers. One of the team engineers commented 'It is good because when you have images you can instantly view the situation. With a probe you must look at just the numbers at that specific point.' The competitive spirit was soon present as it became clear that the imager could be used to

"EMISSIVITY IS THE RATIO OF RADIATION EMITTED BY A SURFACE"

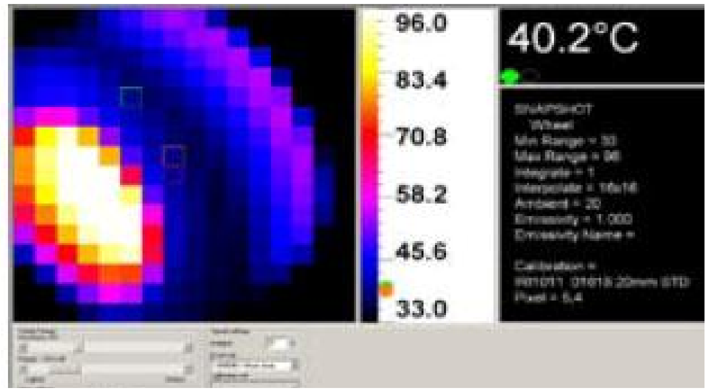
establish what the competition was up to as well. 'It would be great in a series like GP2 because you can see what your competitors' tires are doing without touching them or even being that near to the car.' Something Racecar put to the test, earlier in the day, walking into the back of one team's garage and taking temperature readings from several yards away, without being challenged. Wahl representative (and Formula Vee racer) Andy Woodvine claims 'it's accurate from -10°C (14°F) to 300°C (572°F), so it quickly gives you a snap shot of the whole temperature range of the desired area.

Head-to-head testing started on the A1 Team France car run by DAMS. AP Racing's Nic Olsen used a traditional tire probe to take readings from the car's brake discs, registering a spot temperature of 260°C (500°F), while the thermal imager only recorded a temperature of 160°C (320°F), around a 100°C (180°F) differential. On the surface, It seemed Woodvine's accuracy claims were somewhat optimistic, but Olsen had the answer: 'On carbon discs it would work fine because they are a black body, but once you get a shiny steel disc it can be quite a bit off due to a phenomenon called emissivity. With a probe, although it's a bit basic, it is not upset by emissivity, said the AP Racing man. Infrared measurement is fine with a black surface, but on shiny surfaces, if there is anything like a pad smear or →

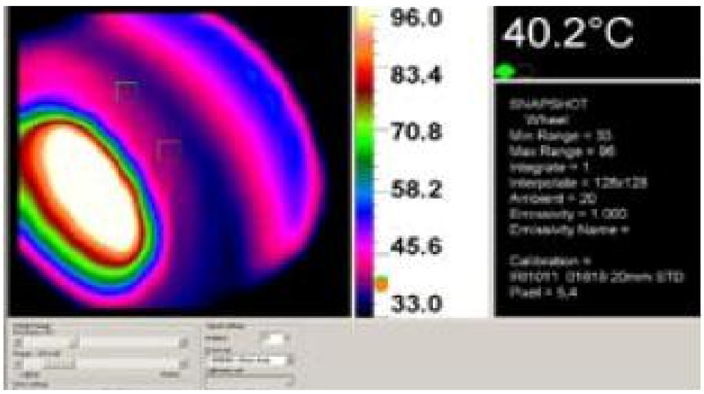
"IT COULD ALLOW TEAMS TO RECORD TIRE TEMPERATURES IN SECONDS"

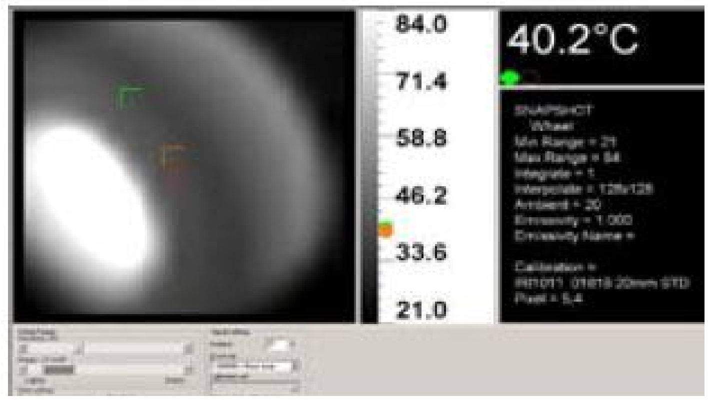


Due to the shiny, reflective nature of the steel surface the camera struggled with brake disc temperatures, but could be adjusted to suit the surface under observation. However, black carbon discs present no such problem.



How the camera "sees" the image-as a series of temperature readings. It then uses built-in software to translate the readings into a user-friendly image. It will take up to 256 data points per image with 10 spot temperatures.





Colors can be adjusted and the amount of color change to temperature can also be adjusted. Racecar found the default setting the best.

Left: in a head to-head test with Nic Olsen's probe on the AP Racing Calipers, the thermal imager performed well.

Right: A1 Team Mexico car with tire blankets fitted just before a tire temp test was run with the thermal imager.

"WHEN YOU HAVE IMAGES YOU CAN INSTANTLY VIEW THE SITUATION"

similar, the variables that you are getting reflected back can change the reading by 100 degrees or more, just by moving around on the disc. In case you are wondering, emissivity is the ratio of radiation emitted by a surface versus what is reflected, by that same surface, of surrounding variables, and varies with how reflective the measuring surface is. For example, a shiny brake disc that is in close proximity to hot exhaust pipe will not only give off it's own heat, but will reflect the heat from the exhaust pipe. With a very shiny surface, perhaps only 10% to 20% of the energy given off belongs to it, the remainder is reflected energy. The perfect radiator, something that is flat black, has a emissivity number of 1, meaning that everything given off belongs to it. A tire is almost the perfect radiator, meaning that what it gives off belongs to it. A tire is the ideal subject for infrared temperature measurement.

Olsen then went on to show that the camera wasn't as unreliable as it had first appeared. 'The caliper will be fine. You'll probably get good results from it because →

Covert temperature readings are easily to gain using the imager, as Woodvine demonstrates without getting too close to the cars. Here the team did not know who he was or what he was doing, nor did they question it.

it's a fairly dull grey body. What we have to do with ours is change the emissivity according to the surface we are trying to measure. I don't know if you can do that on your camera?' replied Olsen, before continuing. 'On our brake caliper, we use a value of 1.1, which is weird because there is not meant to be an emissivity of more than 1, but, it's not an emissivity value, it's more of a fiddle factor.'

In response to this Woodvine demonstrated that it was possible and in fact quite easy to adjust the emissivity on the camera, and then proved its reliability on the car's calipers.

Olsen's pyrometer gave a temperature reading on the caliper of 78°C (172°F), while the camera showed a peak temperature of 81°C (178°F). Pretty much spot on considering the camera under test has a quoted accuracy of ±2°C (±3.6°F). More accurate versions are available, but at a substantially higher cost.

Tires, however, are distinctly non reflective (the emissivity is all their own), and that is where the imager could really come into its own. A quick head-to-head with Olsen's probe showed that the A1 Team France right rear tire was

Readings can be taken quickly and easily in a pit garage or trackside, working around other team members and, and at the same time, keeping out of the way

around 34°C (93°F), while the camera image showed the temperature in that area as being around 33°C (91.4°F). Accuracy then is not an issue on a tire, and also it will store every image you take – after all it is effectively just a digital camera taking thermal images.

In a head-to-head test on the A1 Team Mexico car (also run by DAMS) the thermal imager worked equally well, giving accurate temperatures faster than a pyrometer and in a far more informative way. As the car's tire blankets were removed, Woodvine took an image of the rear tires. The result showed the edges of the tires were evenly heated but there was inconsistency with the middle portions, suggesting perhaps that the blanket was not in consistent contact with the tire surface. After a three-lap run the car showed relatively even heat distribution across both rear tires, the camera again out performing the probe.

Of course the issue of capturing rivals' tire temperatures is a very relevant one in a series like A1 Grand Prix, GP2, or even F1, and it's not surprising that a number of Formula 1 teams expressed an interest in the imager when Racecar approached them. However, equally unsurprisingly, they were not happy with the results being published. After all, imagine if a rival team could stand at the front of your team's garage and take your tire temperatures without ever going near the car... 'The imagers use a fixed focus lens, so the field of view increases as the distance increases. At five meters (16 feet) the 'hot spot' – that is one pixel – is 11cm (28 inches) of the surface you are measuring, but the area within the pixel gets smaller and more accurate as you get closer,' explains Woodvine. 'And it can see differences in temperature of as little as half a degree.' This is with the standard 20° field of view camera. There is a 10° field of view unit, covering half the area at the same distance.

"IT MUST SURELY BE THE NEXT ESSENTIAL ADDITION TO A GOOD TEAM'S KIT"

The imager we tried out in tests at Silverstone did show a lot of potential, but the engineers and software developers at Wahl could really benefit from working with a racing team to develop a set of emissivity readings for commonly found surfaces in motor sports. Having said that, even in its current form, an engineer could still use the thermal imager to find real benefits.

One thing remains to be asked then – why doesn't everyone use them? Quite simply because accurate thermal imagers have always been out of what many would consider a realistic price range, but the Wahl imager, like the one we tested can be bought starting at $3499. More than a very good quality thermocouple probe, certainly, but, as with most things, you get what you pay for – in the case of the thermal imager, what you get is increased functionality, faster, more in-depth readings, instant analysis, the ability to save the images for future reference, and, of course, the potential to spy on your rivals. Other than the cost issue it must surely be the next essential addition to a good team's kit.

In the meantime Racecar is going to continue to test the device and possibly to work with racecar manufacturers to develop a specific motor sport spec version.