

## Why Ignoring Emissivity in Thermal Camera Testing should not be a Gray Area

Thermal imaging is a proven technology for nighttime sensing that was for many years the exclusive domain of the defense industry. Nascent adoption by the automotive industry presents a new challenge by requiring the manufacture of these devices in historically high quantities. In addition to manufacturing capacity and pricing pressure, the ability to test performance with reliable instrumentation will also be critical in order to ensure that acceptance criteria are correctly applied. Characterizing thermal detection is tricky due to variability and instability in radiation efficiency (graybodies vs blackbodies). Even when high-emissivity coatings are used test targets the collimating optics through which these are viewed will generally attenuate emissions. This uncertainty can reduce apparent yield, and bottleneck a good production run via erroneous test results.

It is natural to simply describe the function of a thermal camera as a device which can “see” temperature. But no body emits thermal radiation with 100% efficiency, resulting in a loss of contrast between the body and its environment. Just as emissivity influences a thermal image in the real world, the emissivity of a test target skews results during performance characterization. Implementing standardized metrics such as Minimum Detectable Temperature Difference (MDTD) and Minimum Resolvable Temperature Difference (MRTD) requires a means of accounting for non-unity emissivity in the test setup. This is important not just so that measurements from different test systems may be compared with one another, but also to compensate changes in emissivity which have been shown to occur over time. Ignoring these considerations risks introducing a systematic error that can significantly affect apparent yield in the short and long term.

Infrared radiometers are devices which characterize the relationship between radiometric temperature—the blackbody temperature “seen” by a thermal camera—and the physical temperature of a radiation source. Although it is strictly the radiance of sources that are related by their emissivities, over a modest temperature range the radiometric and physical temperatures are linearly related to a very good approximation. Radiometry at longwave infrared (LWIR) wavelengths is especially tricky due to thermal radiation emitted by the radiometer itself. Selecting signal from background and careful system calibration makes the design of such an instrument nontrivial.

As thermal imaging gains traction in developing better automotive safety systems, we can take advantage of lessons learned and techniques developed by the defense industry. Infrared radiometers have served this sector for decades, usually for characterizing test setups that were designed for larger thermal cameras than those required for light vehicles. Since radiometers are generally sized according to the scale of the camera that will eventually be tested, the primary challenge is the miniaturization of the existing detection schemes (Figure 1).

Maintaining the calibration of an infrared radiometer is a challenge in and of itself. With environmental temperature coupled into the background signal received by its sensor, the calibration should account for radiometer performance over a range of room temperatures. The

standard against which the radiometer is compared is typically a fluid-controlled blackbody source with a calibrated temperature probe.

The complexity of radiometers and the process of establishing their traceability highlights a need for a calibration service that can support the higher volumes expected from automotive applications. An organization with institutional experience in thermal imager metrology and a robust quality management system will be ideal.

In this presentation, we discuss the design of an infrared radiometer using the Optikos RAD-900 as an example. We also show sample datasets from the radiometric calibration of a thermal test bench (Figures 2 and 3) and discuss the calibration chain required in order to maintain a radiometrically calibrated thermal target projector system.

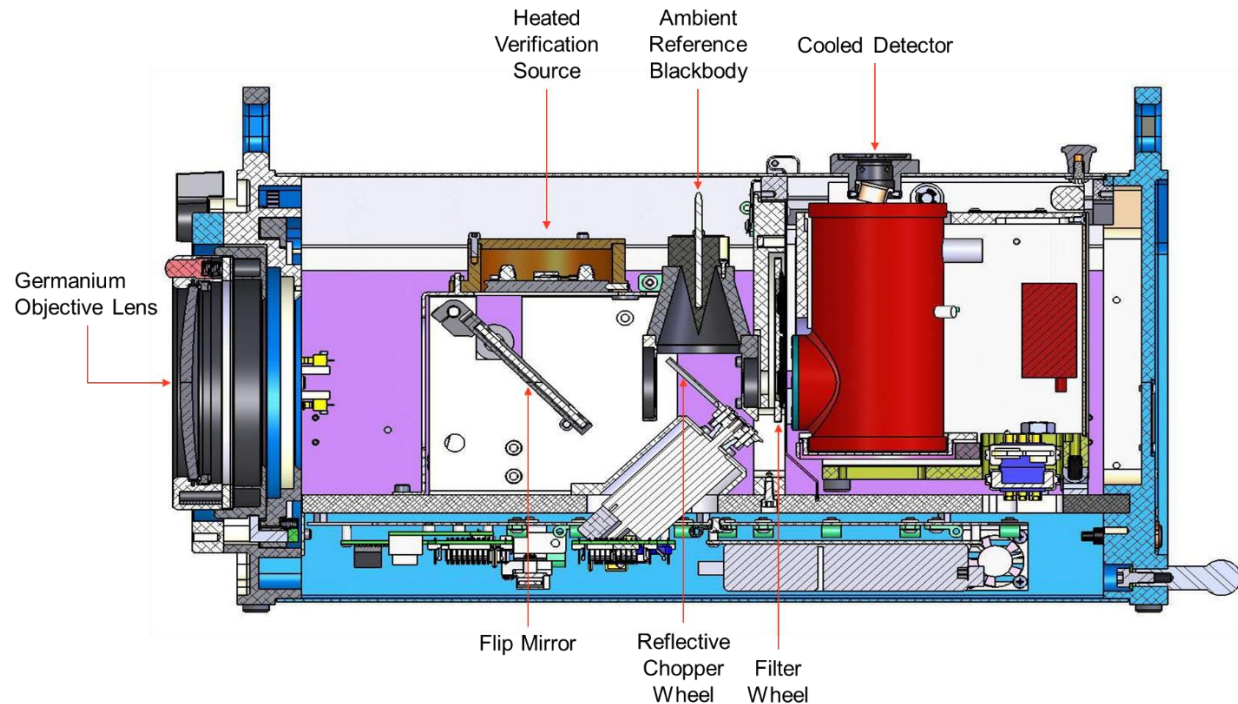


Figure 1. Cross sectional view of the Optikos RAD-900 scanning infrared radiometer with key subsystems noted.

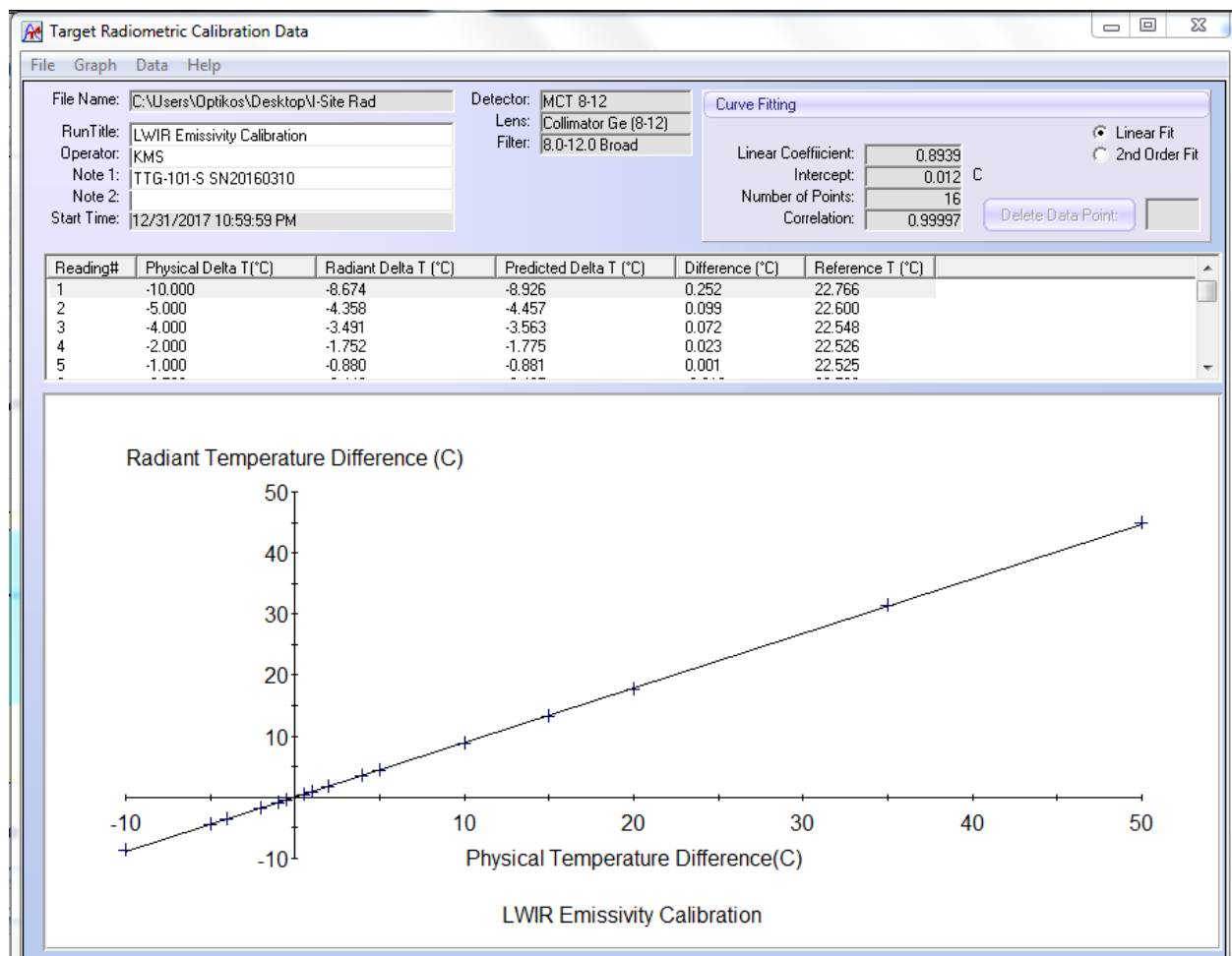


Figure 2. Measured relationship between Radiant Temperature and Physical Temperature of an LWIR target projector with calculated Linear Coefficient and Intercept values which may be implemented as correction factors.

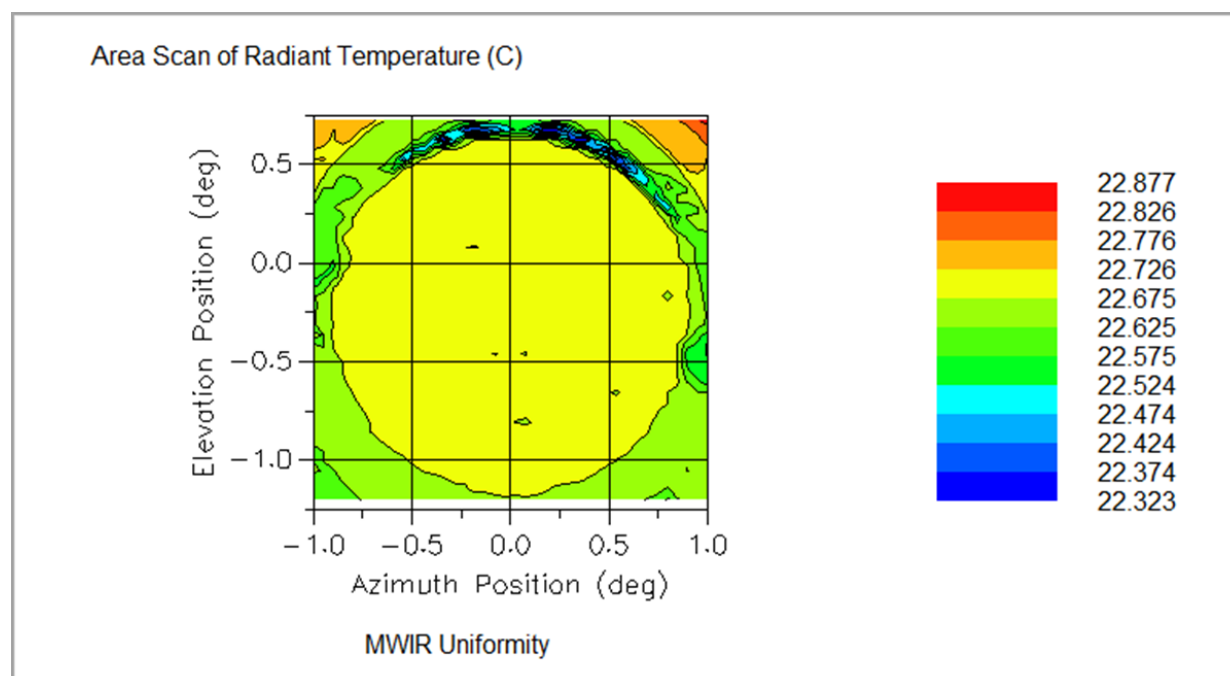


Figure 3. Radiant temperature uniformity measurements of a projected thermal source obtained by performing a 2D scan with the radiometer.