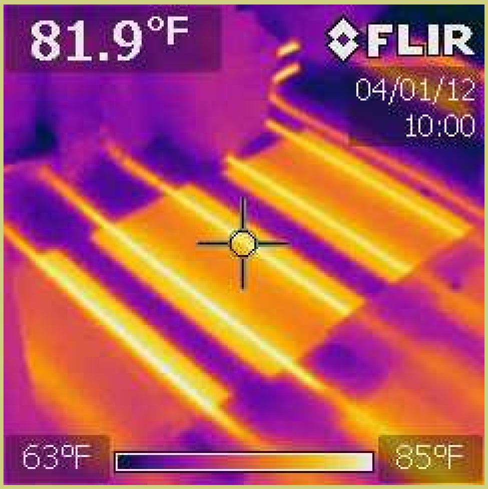
Assorted Technical Expertise at
Rattlesnake Ridge Research

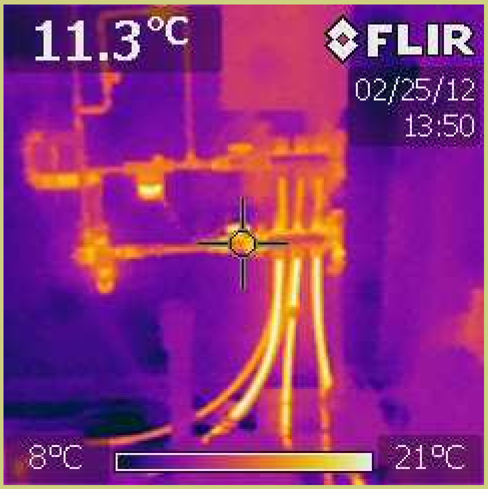
Fun with Thermal Imaging

In the spring of 2012 I bought a FLIR i7 Thermal Imager. I've always wanted one, since back in the day when these things cost $30,000 and required a supply of liquid nitrogen. Back when I was at Artech I learned it was possible to make a living with one of these just doing preventive maintenance in industrial plants. I worked with thermocouples a lot, but always wanted a thermal imager so I could get the big picture. With a tool like that, I'd know if I had the thermocouples in the right spot.

The preventive maintenance applications are clever. Bearings typically start overheating before they fail, so surveying conveyor lines or similar mechanical equipment in advance of a scheduled maintenance shutdown will generally reveal the ones that need replacing, avoiding a costly emergency shutdown. Electrical panels and connections frequently get hot when experiencing overloads or bad connections, so a thermal imager can often go right to the failure.

When I found FLIR had models priced $2000 and under, I knew I could finally afford one for personal use. I was just installing the last oak floor boards over the radiant heat floors in our West Virginia cabin, and thought the satisfaction of seeing the heat distribution would be worth the price of the 140 x 140 pixel i7 model. I was amazed at the sensitivity of this little tool. It clearly shows the tubing and heat distribution plates. In the left picture below, the sharper part of the image is uncovered tubing and plates, but the adjacent sections covered with ¾" oak flooring show these components remarkably well. The picture on the right is the distribution manifold and pump system.





Figures 1, 2. Radiant heat system.

Figure 3 looks like a picture of the sun. It is actually a shot of a cup of coffee just after adding milk. The convection cells are plainly visible.

Figure 4 is a shot of a section of siding above a window with a chronic leak problem. By timing the shot the morning after a hard rain, with the sun just hitting the siding, the source of the water is plain to see. This technique of applying infrared heat to a hidden leak will often reveal it.

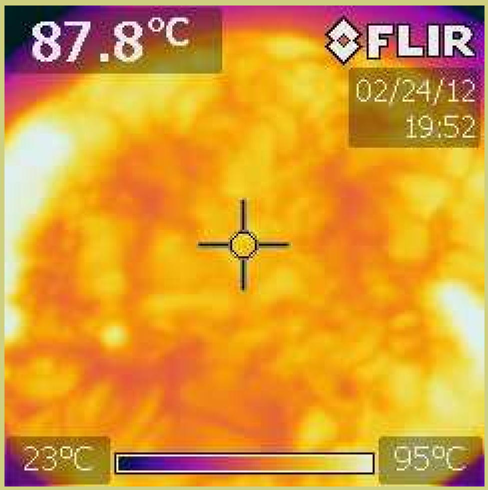


Figure 3. Convection cells in coffee.

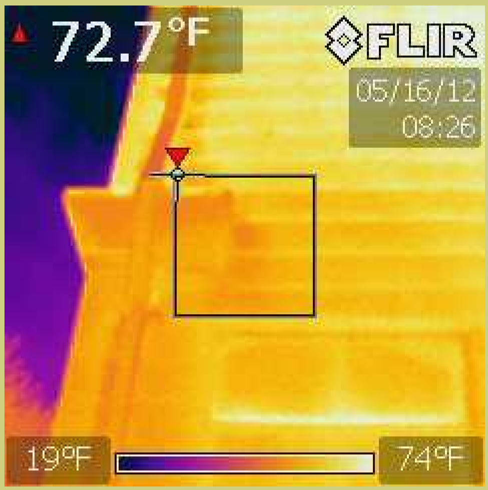
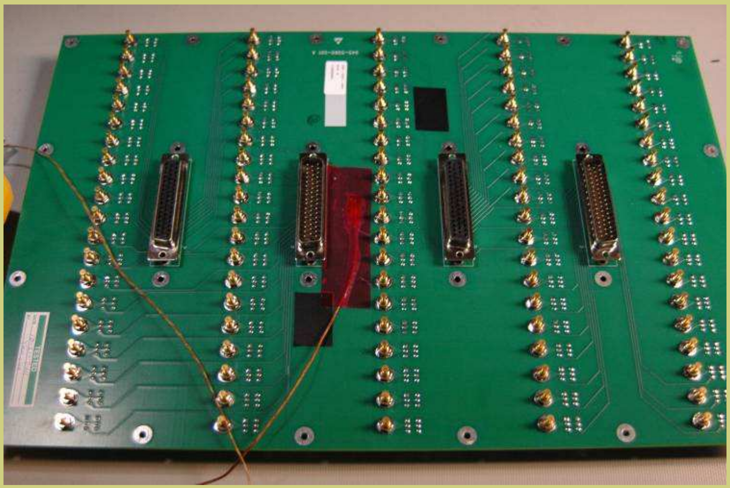
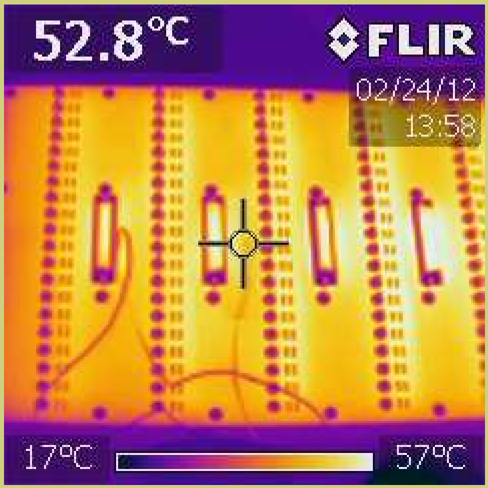


Figure 4. Leak behind siding.

Imaging circuit boards is a common application for infrared. I was interested in using the camera to verify that the thermal emissivity of the circuit board material was close to the ideal of 1.0. There are several ways to check this. I applied a thermocouple (under the red tape), as well as two strips of black electrical tape (typically an emissivity of about 0.95). The right image is one of a series of images of the board made as it cooled down from a 70 C soak in an oven. There is no contrast at the pieces of tape, which means the thermal emissivity is all about the same (not unexpected for organic material). But the shiny metal parts, which are gold plating, fresh solder, and plated steel, all show up as cold, because their thermal emissivity is very much lower than the organic materials. The thermocouple was in good agreement with the imager, but did reveal a slight bias in the imager. The measurement did include a compensation for the thermal emissions of the room.





Figures 5, 6. Thermal image of a circuit board.

In amateur astronomy, there is a long-standing recommendation to put the telescope outside well before your planned observing session. The reasoning is that you want to minimize convection within the telescope tube, which causes degradation of the image. The two images below are of my 8” Celestron telescope just after being placed outside from the warm cabin and after cooling to near ambient over 78 minutes. Once cooled, the telescope nearly blends into the background, but the trees have clearly retained daytime heat.

Pointing the camera at the nighttime sky is highly informative. Clouds really stand out. They’re *dramatically warmer* than clear sky. We are usually told that clouds act as a blanket, but any time water vapor condenses, it gives up copious heat. The contrast to the near-absolute-zero of deep space is dramatic, and an amateur astronomer will see at a glance why no stars are visible in a particular portion of the sky. The IR band the i7 uses is one where water vapor strongly absorbs IR. This limits the range in humid conditions, but it also gives the camera the ability to see steam or water vapor from combustion.

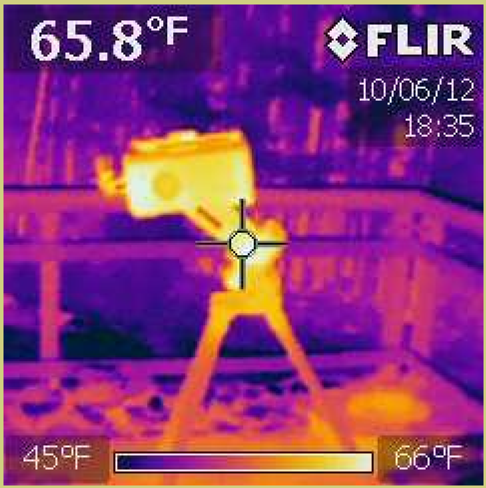


Figure 7. Telescope before cooling.

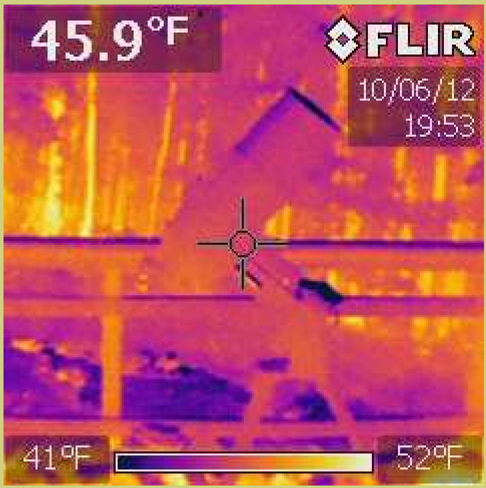


Figure 8. Telescope cooled to ambient.

Have you ever wondered how much propane is left in a cylinder? There are a number of thermal methods for checking this, but few are more convenient that a shot with a thermal imager. In heavy use, the propane will be considerably cooler than ambient.

The i7 is not a surveillance tool, but could be pressed into service if needed. Back when I did ground search and rescue in the Civil Air Patrol, this gizmo could have proved a lifesaver. Figure 10 shows two people standing on the far side of our neighborhood lake, behind a short low rock wall (still warm from the sun), at a distance of about 100 yards, after dark. I pointed the camera at cold water and my hand to set the temperature range, and toggled it to not autorange. This meant warm human skin would stand out against the cool background. Thermal imaging could make a timely rescue possible in a nighttime drowning situation.

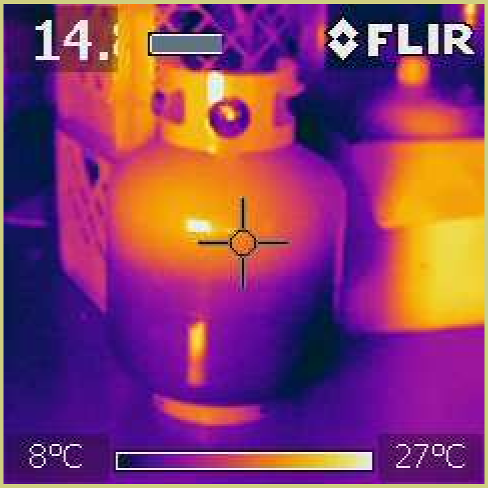


Figure 9. Propane cylinder fuel level.

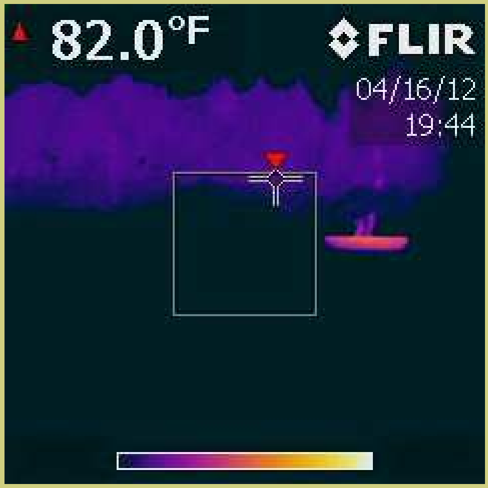
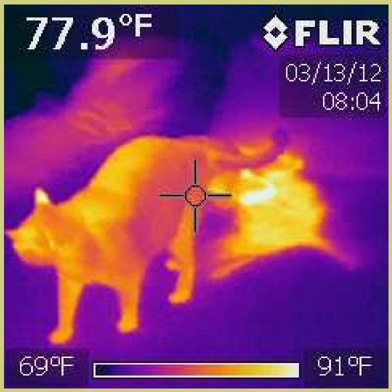


Figure 10. Detecting people.



I remember once seeing the description of a military IR sight as being "so sensitive it can detect the body heat of a tomcat from a hundred yards." The i7 is not only sufficiently sensitive to see the body heat of a tomcat, it can see where he lay and track his footprints. It also does this with human handprints and footprints.

Figure 11. Where the cat lay shows easily.

My little i7 is limited to low resolution still pictures, although the viewscreen shows updates at 9 Hz. Some of the higher-end models produce videos. There are also models adapted to microscopes, another tool that could practically be a business by itself. I recently saw a demonstration of a FLIR shortwave thermal imager working in a band where hydrocarbon gasses absorb the wavelengths. It can see gas leaks.