

Passive cooling of an astronomy camera housing using SRI's Self-Cooling Paint™

Results of an independent field test

Outdoor electronics housing needs to keep camera and electronics cool

Outdoor electronics enclosures may contain heat generating components while simultaneously accumulating daytime solar heat, particularly in warm, sunny weather. This cumulative internal and external heat load can lead to damage, shutoff/service interruption, or a shorter lifespan of the electronics, necessitating costly replacement. Therefore, an affordable, easily applied, passive, exterior radiative cooling paint coating that can reduce or eliminate solar heat gain while dissipating heat is of significant value. Based in the Raleigh, NC area, Geek Field Guide LLC designed a camera system with a unique exterior housing for all-sky photographers. The system needs to withstand daytime temperatures reached under solar exposure without overheating the components, while quickly removing accumulated heat. Specifically, overheating of the camera sensor was known to cause images to contain extra digital noise, reducing accuracy and image quality. The objective of this test was to use Self-Cooling Paint to help keep the temperature of the housing low. Both the unit design and the coating were considered critical elements to optimize for maximum cooling.

SOLUTION

Self-Cooling Paint is a passive radiative cooling solution – without requiring any power or electricity, it can cool down any surface up to 5-8 °C (8-12°F) below ambient temperature*, and 15-30 °C (20-50 °F) below ambient on an uncoated surface.** Achieving subambient temperature is significant and has been accomplished by engineering this paint coating that combines high solar reflectance with high infrared emittance in the atmospheric transparency window. The initial “Baseline” design of the electronic enclosure was 3D-printed using acrylonitrile styrene acrylate (ASA), with plain cylindrical walls. Design 2, also 3Dprinted ASA, was painted with SRI's Self-Cooling Paint. Geek Field Guide conducted design iterations, referred to as “Finned-design” to 1) maximize thermal conductivity of the wall to effectively remove heat from inside of chamber by using carbon fiber-filled ASA (CFASA) material, 2) enhance radiative surface area of the enclosure wall by creating fins, and 3) minimize the thickness of the enclosure wall to reduce the thermal resistance.

APPROACH

The effectiveness of the Self-Cooling Paint was determined by collecting temperature data from multiple thermocouples placed inside and outside the housing. Data from both uncoated (Baseline) and coated units (both Design 2 and Finned design) was collected for comparative purposes. The paint application process and surface appearance was also assessed.

Multiple temperature sensors were placed at different locations, including in the dome and in the interior and exterior of the housing. Test units were placed outdoors, in an area receiving direct sun for most of the day.

“Without any structural design changes, the paint alone dropped the peak interior temperatures versus the exterior surface by about 4 degrees C°.”

Warren Schultz, Geek Field Guide LLC



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APPLICATION

The Self-Cooling Paint was sprayed directly on the surface of 3D printed ASA and CF-ASA enclosure.

The paint was applied in March – April, and in July – August of 2025 timeframe, in a garage in Raleigh, NC, and left in ambient conditions for drying and curing without any external heat required. The thermocouples were glued with polyimide tape and thermally conductive paste.

Paint adhesion was observed to be good, even without any application of a Primer. The painted surface was acceptable, with the surface finish mostly determined by the 3D printed surface, rather than paint, which conforms to the ridges created by the 3D-printer, as shown.

RESULTS

Geek Field Guide reported 1) temperature differentials between the dome air temperature that the camera is directly experiencing and the outdoor (ambient) temperature, and 2) temperature differentials between CPU temperature and the outdoor (ambient) temperature. For comparison purposes, they reported these two temperature differentials for Baseline, Design 2 and Finned-design enclosures, shown in the figures below. Baseline and Design 2 were tested in March and April of 2025, where peak solar fluxes were $\sim 800\text{W}/\text{m}^2$, and $>950\text{W}/\text{m}^2$. The Finned-design was tested in August 2025, where the Peak Solar fluxes were $>950\text{W}/\text{m}^2$. The solar fluxes are shown below, corresponding to the three test periods.

Even with increased Solar fluxes, Self-Cooling Paint kept overall temperatures inside the Design 2 and the Finned-design enclosures relatively colder than Baseline, with Zero energy consumption or any fan deployment at all.

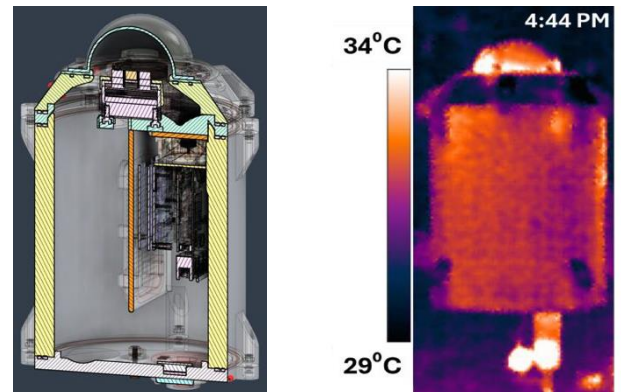
For example, the temperature differential between dome air v/s ambient temperature at peak solar hours reached up to $>22^\circ\text{C}$ with peak solar $\sim 800\text{W}/\text{m}^2$, while in Finned-design, it was $<15^\circ\text{C}$, even with peak solar $\sim 1000\text{W}/\text{m}^2$.

COMPONENTS

- Camera housing
- Self-Cooling Paint
- Iwata HP-TH2 air-brush sprayer
- T-type, calibrated thermocouples, used as temperature sensors
- Digilent MCC 134 Data acquisition system (DAQ), used to collect the data with Raspberry Pi and Python script
- Weather monitoring unit, used to collect solar flux and wind condition data
- InfluxDB and Grafana, used to store and analyze the timeseries data



Thermal image of Finned-design. Note the painted sky-facing surface is colder than the shaded side.



Camera housing, Design 1, with clear acrylic dome covering the anodized-aluminum camera. Red dots indicate thermocouple locations.

Thermal camera image of camera housing, showing cooler (dark purple) sky facing surface

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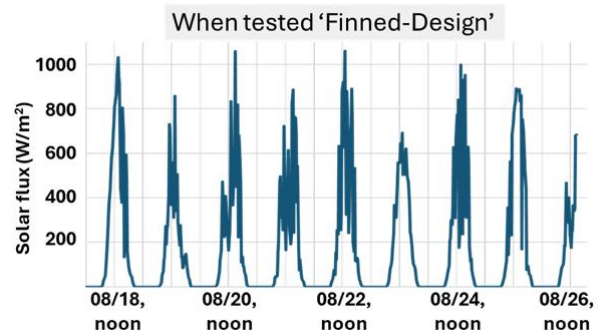
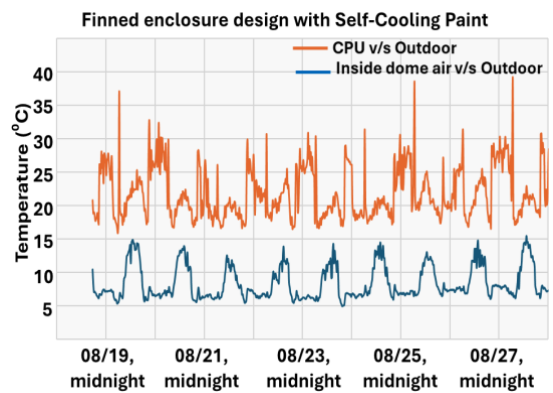
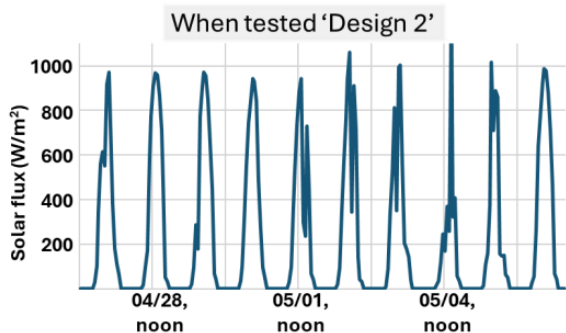
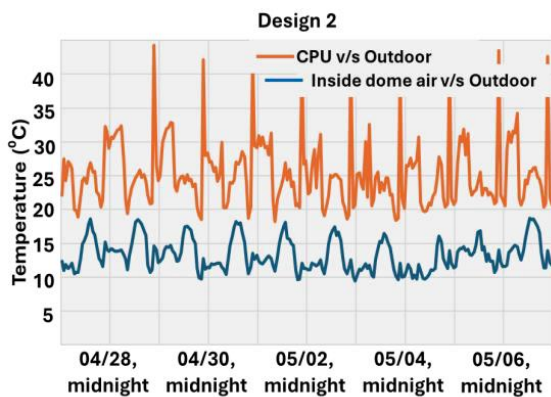
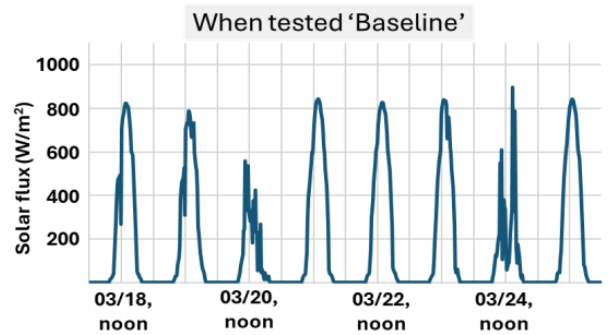
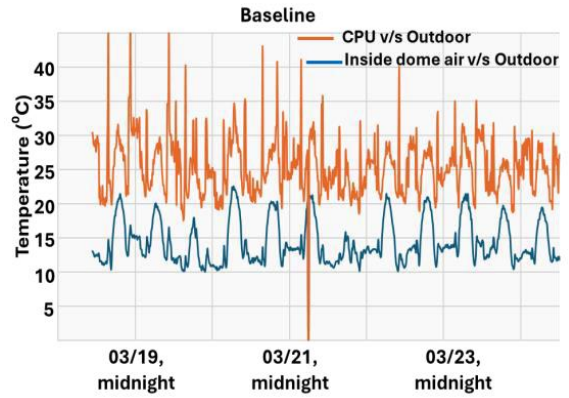
TEMPERATURE MEASUREMENTS

A thermal camera was used to take images of the surface during the initial deployment of the painted enclosure. Thermal images show that the sky-facing painted surface is almost 3°C - 5°C cooler than the vertical surface, inferring the benefits of radiative emissions of SRI's Self-Cooling Paint in the atmospheric transparent window.

Data from the Baseline design was collected from an uncoated unit in March and from a Self-Cooling Paint coated Design 2 in April. The Finned design coated with Self-Cooling Paint was tested in August, after making both material and design changes in the enclosure to maximize the utilization of the cooling effects of the Paint. In each unit, temperature sensors were mounted in similar locations.

During the tests of recording temperatures while the camera was in operation inside the enclosure, the camera setup ran 24 hours a day. During the day, it took short, periodic exposures for timelapse generation. Once the sun went down, it switched to longer exposures for the night sky. It ran exposures back-to-back all night.

You can usually see a heat spike in the processor (and sometimes internal air temperature) shortly after dusk and dawn, as the timelapses were generated by processing the previous period's images into an MP4 file.



* Ambient temperature is measured by placing a temperature sensor outside in air. The sensor used is the same kind as the one used to measure surface temperature.

** Internal tests conducted on aluminum substrate, and with a convective shield. Photos courtesy Warren Schultz, Geek Field Guide LLC

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CONCLUSION

Self-Cooling Paint clearly reduced exterior surface temperature and the temperature around the electronics inside the enclosure.

The combined effect of Self-Cooling Paint and an optimized enclosure design that maximized heat dissipation was the most effective; The peak interior air temperature of the air to which the camera was exposed while in operation was $<15^{\circ}\text{C}$ higher than ambient, whereas it was $>22^{\circ}\text{C}$ hotter in the unpainted Baseline unit, even with much less peak solar flux demonstrating that Self-Cooling Paint was able to keep the camera colder inside the enclosure with the best design to effectively realize the potential of Self-Cooling Paint. This lower camera temperature will help the user collect better high-resolution images and avoid issues associated with overheating.

About SRI

SRI is an independent nonprofit research institute, headquartered in Menlo Park, California., with a rich history of supporting government and industry. We create and deliver world-changing solutions for a safer, healthier, and more sustainable future. For more than 75 years, we have collaborated across technical and scientific disciplines to discover and develop groundbreaking products and technologies and bring innovations and ideas to the marketplace. Learn more at www.sri.com.

Contact

Contact SRI to inquire about partnership or licensing of the paint

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