**Project Summary**

**Passive Radiative Heat Pump Surfaces for Urban Cooling**

Cities in the US are warming faster than the global average due to the choice of materials for buildings, roads, and other urban infrastructure, and as a result of waste heat emissions into the urban airshed. This local warming is further exacerbated by global climate change and associated feedbacks. Warming in cities has adverse consequences for the health and well-being of residents, including increases in heat-related illness, energy use for air conditioning, air pollution, and water use. As a result, cities are seeking solutions to mitigate extreme heat. However, there are two vexing barriers that planners and government officials need to overcome.

First, city governments are risk-averse and generally unwilling to experiment with new technologies or strategies. Proof-of-concept data from living laboratory experiments involving new urban cooling strategies can overcome the technical, political, and institutional barriers that unnecessarily slow innovation in this space. Second, urban cooling strategies can be costly to implement across the entire city. This points to a need for information regarding the spatial variation of extreme heat across the city to help inform targeted mitigation efforts.

This project addresses both of these challenges through a partnership with city government (Tempe) and industry (3M) to deploy and evaluate the performance of an innovative urban cooling technology while simultaneously developing a sensor network for tracking variations in thermal conditions across the city.

The urban cooling technology being tested—radiative films—is made possible by recent advances in materials science that enable the creation of coatings and films with extremely high reflectance to the sun’s energy while also being very efficient at radiating the surface’s own thermal energy out of the urban environment. If such a film is installed on an urban surface such as the roof of a bus shelter, that surface can actually remain cooler than the air temperature at all hours. As warm air flows over these surfaces, heat is removed from the air and then the surface radiates this heat out of the urban environment, and largely into space. For this reason, we refer to this approach as a radiative heat pump.

This project will evaluate surface and air temperature cooling potential of radiative films through a measurement study involving bus shelters in the City of Tempe. Three relatively isolated and unshaded bus shelters will be outfitted with 3M radiative films on their roof surfaces. An additional three shelters in similar environments will serve as controls. Small form-factor data logging temperature sensors will monitor shelter surface and air temperatures for a year. Additional episodic measurements will explore thermal comfort of bus shelter patrons at various times throughout the year.

A second element of this study is the deployment and testing of a unique RFID-based sensor technology that offers the promise of creating a dense, yet inexpensive network of urban temperature measurements integrated in mass transit infrastructure. This testing will leverage the planned measurements at the City of Tempe bus shelters by co-locating RFID-based temperature sensors and testing a system for acquiring thermal data from moving vehicles.



A qualitative representation of radiative film technologies applied to the roof of a pedestrian shelter.