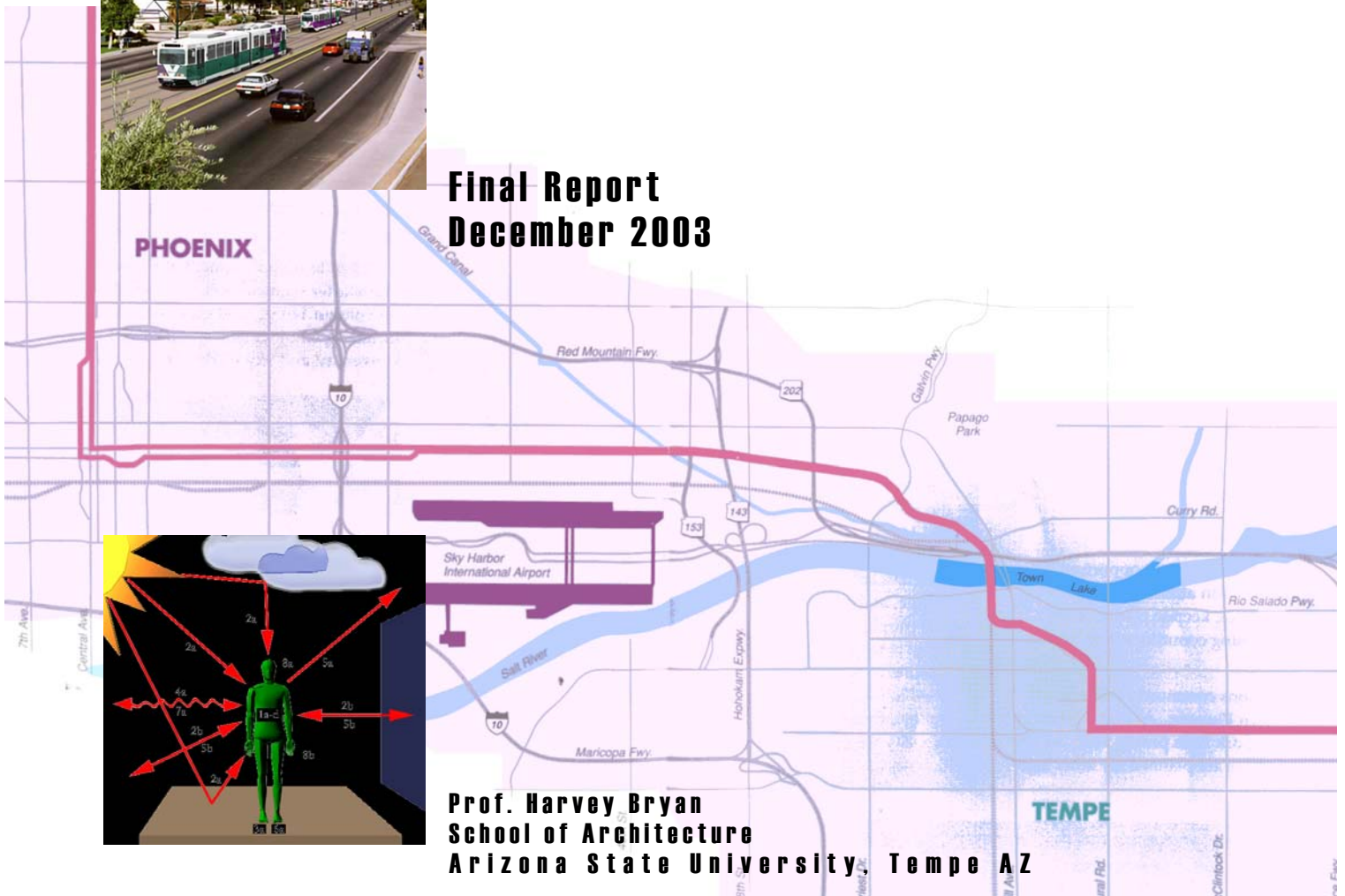




Surface Temperatures of Proposed Station Materials Valley Metro Rail

**Final Report
December 2003**



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INTRODUCTION

In the design of open air-stations the concept of microclimatic modification by architectural intervention was established by two earlier reports to Valley Metro Rail, "Climate, Comfort and health,"¹ and "Cool Architectural Materials and Assemblies." These reports found that many of the outdoor shading structures and paving surfaces have not been appropriately designed for hot arid climates like Phoenix. Many of the shading structures use dark single-ply light gauge metal as the primary shading surface that turn them into solar collectors. Also, many of the paving surfaces use dark asphaltic materials or an overuse of concrete which absorb and retains heat long into the evening hours and significantly contribute to the serious heat island phenomenon in Phoenix. Activities around these materials are strongly impacted by radiant heat during hot summer days. Local field measurements of a number of these materials found that it is not uncommon on a summer day to have surface temperatures of 150°F (65°C). Such high temperature on such large radiative planes a few feet from a user creates significant thermal discomfort and health stress.

The reports mentioned above outlined a number of approaches to mitigate the thermal discomfort in open air-stations and proposed analytical techniques for calculating their effectiveness. The fundamental opportunities for modifying human comfort in open air-stations in a hot arid climate was to control as much as possible the mean radiant temperatures of the building material surfaces that impact users. Since these reports were generated, several potential building materials were presented to Valley Metro Rail staff that were claimed to depress surface temperatures as compared to conventional materials. Researchers at Arizona State University, School of Architecture, were asked to verify these claims by undertaking performance testing of the materials under question. The materials were tested in this study were IRIS, an Infra-Red Insulation System - a specialty coating system that has claimed to depress surface temperature of metal panels as compared to conventional coatings on metal panels of identical color.

1.0 Metal Panels with IRIS Technologies, LLC. Coatings

1.1 Introduction:

Tests were performed at Arizona State University's Solar Laboratory on a series of colored metal panels during the months of August and September 2003. Anthony Skelhorn of IRIS Technologies, LLC. supplied all of the colored metal panels. The testing consisted of surface temperature measurements of 3 sets of 6 panels IRIS Technologies, formulated three different coating systems and applied them to 24" x 24" metal panels, and named them "ThermaShield IRR", "IRIS – ThermaPrime & ThermaShield IRR Semi Gloss" and "IRIS – ThermaPrime & ThermaShield IRR Eggshell." Each test set also incorporated 3 different colors, which IRIS Technologies named "Heirloom", "Tweed" and "Sequoia Brown." "Heirloom" is close in color to off-white, "Tweed" is the color of beige and "Sequoia Brown" is dark brown in color. Each test was conducted on a sloping south facing test rack, with the IRIS Technologies panel placed next to a similar metal panel, coated the same color using a conventional type of paint. Each test set was tested for approximately 7 to 10 days with automated surface temperature measurements being taken every 15 minutes. One representative of each coating type and color for a typical day are presented in the following graphs.

1.2 Test setup:

The following test setup was used to carry out the tests to measure surface temperatures of the metal panels with an Infrared Reflective Coating:

- An inclined metal frame, facing due south, and away from any obstructions so as to avoid shading; was set up with Styrofoam boxes, which had holes at the bottom for venting out the space below the panels. The panels were lifted off the edges of the boxes, so as to facilitate ventilation and to ensure that no heat was trapped inside the boxes.
- The panels with conventional coatings were fixed on the left hand side.
- The panels with the different infrared reflective coatings were fixed on the right hand side.
- Thermocouples were fixed to the front and back surfaces of each panel to record the surface temperatures.
- In addition to these, instrumentation was also set up for readings for h_o , I_{TO} and t_{air} .

1.3 Test Procedure:

The data-loggers were set up to take readings every 15 minutes. Each set was kept in place for at least 7 days, to ensure consistency of data. Even though front as well as back surface temperatures were recorded, the back surface temperatures were consistently found to be lower than the front surface temperatures by a constant amount; i.e. they were simply a function of the front surface temperatures and the conductivity of the metals. Since the same metal panels were used for all tests, the back surface temperatures were ignored for further analysis. After the surface temperature tests were carried out, smaller pieces (3" x 3") of the metal panels with these coatings were cut, and duly labeled and tested for emissivity using an emissometer.



Figure 1: Test Setup for the Metal Panels and Coatings

1.4 Results:

The following observations were recorded:

- As mentioned earlier, the back surface temperatures were consistently at a constant 2-3 ° F lower temperature than the front surface temperatures, across all coatings and colors.
- The results did not vary as significantly across categories, as they did across colors.
- For the “Heirloom” panels, the benefit by way of lower surface temperatures was in the range of 3-5 ° F.
- For the “Tweed” panels, the benefit by way of lower surface temperatures was in the range of 6-8° F.
- For the “Sequoia Brown” panels, the benefit by way of lower surface temperatures was in the range of 9-11 ° F.
- That is, the darker the color, the greater the benefit by way of lower surface temperatures.
- The emissivity tests showed all of the coatings to have very close values of emissivity to each other, as well as to the conventional coating when readings for samples of the same color were compared.

The accompanying graphs on the next four pages show the temperatures for a representative day, followed by the results of the emissivity tests:

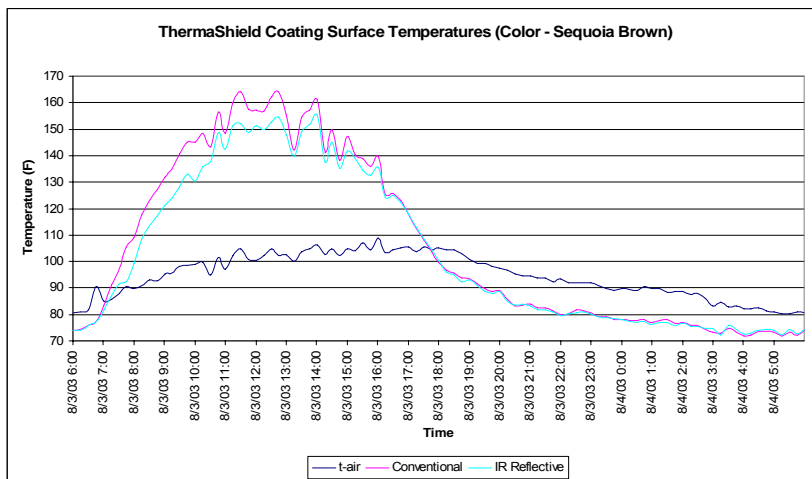
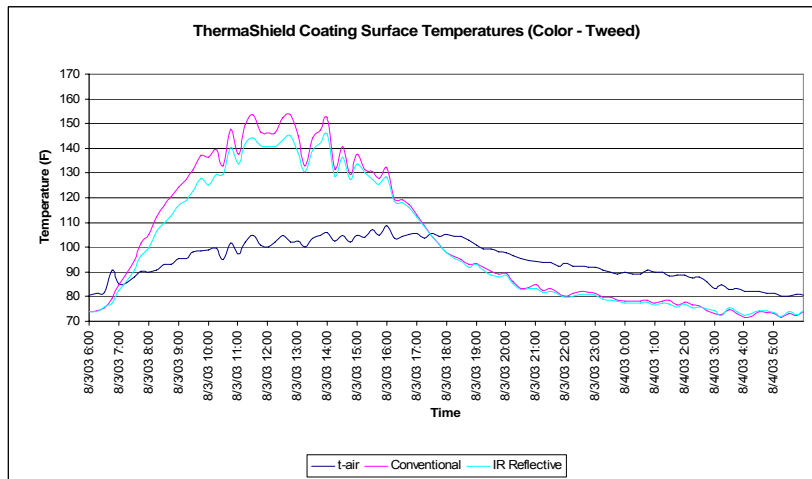
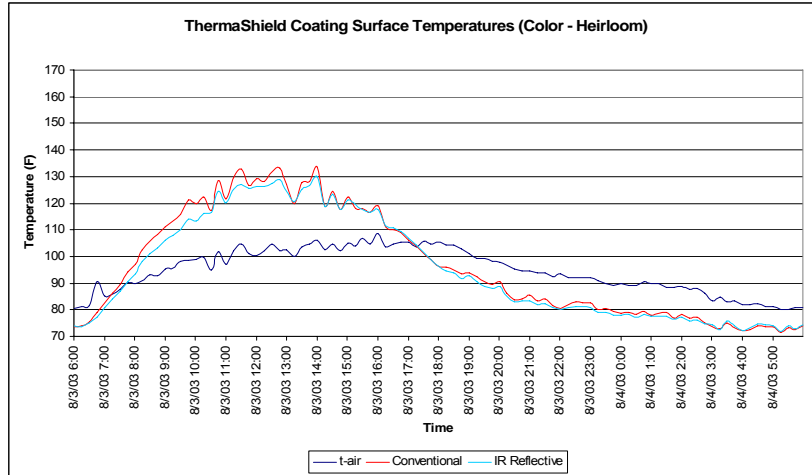


Figure 2: ThermaShield IRR Coating Surface Temperatures

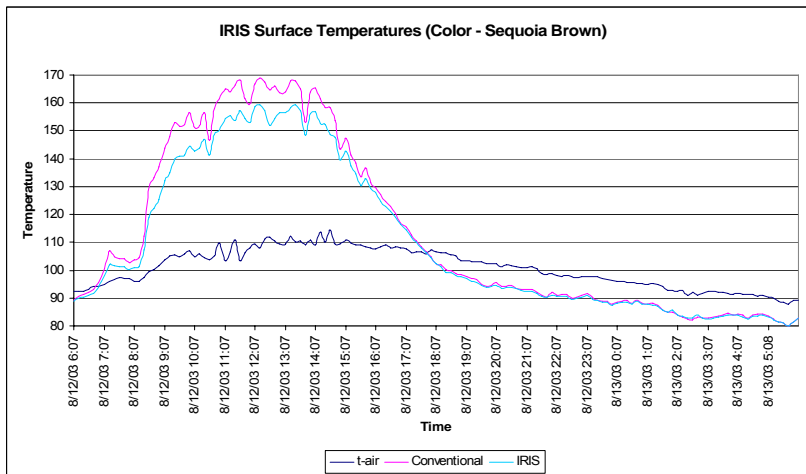
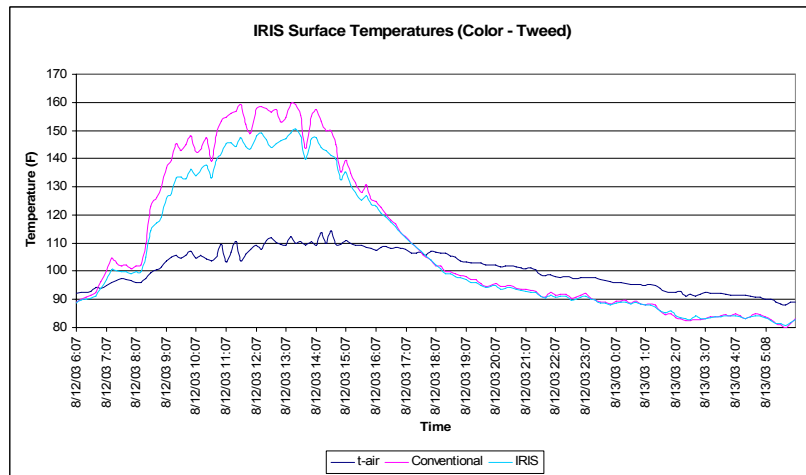
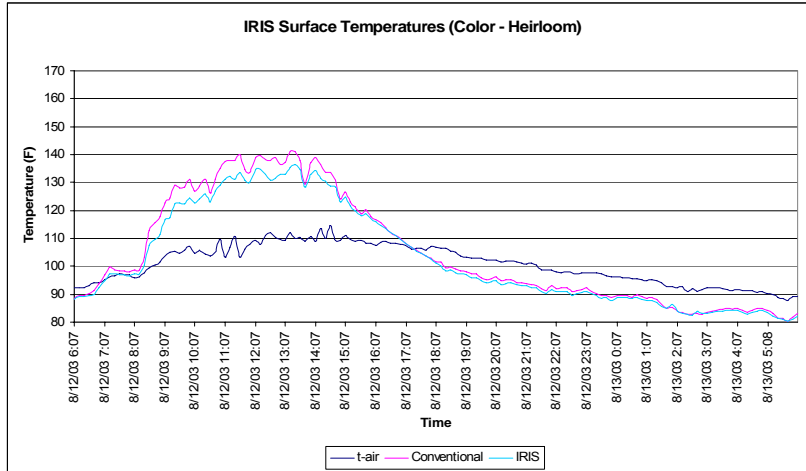


Figure 3: IRIS Semi-Gloss Coating Surface Temperatures

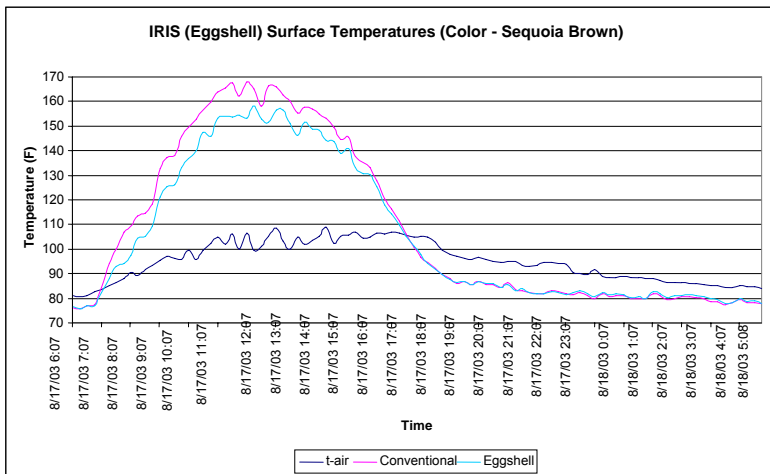
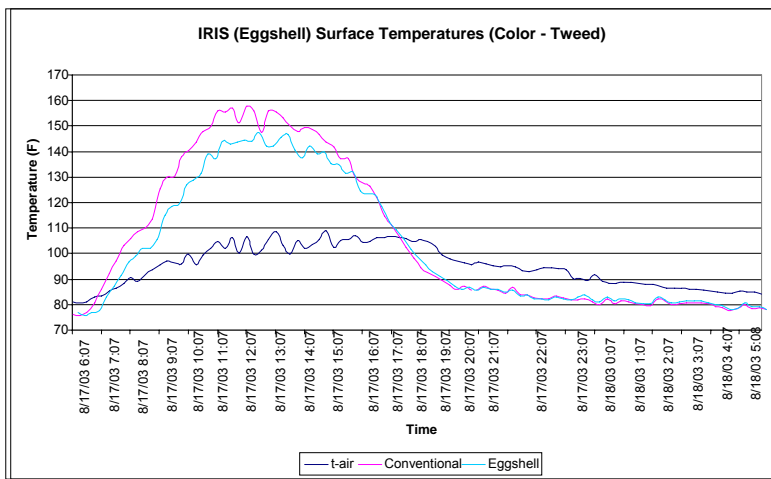
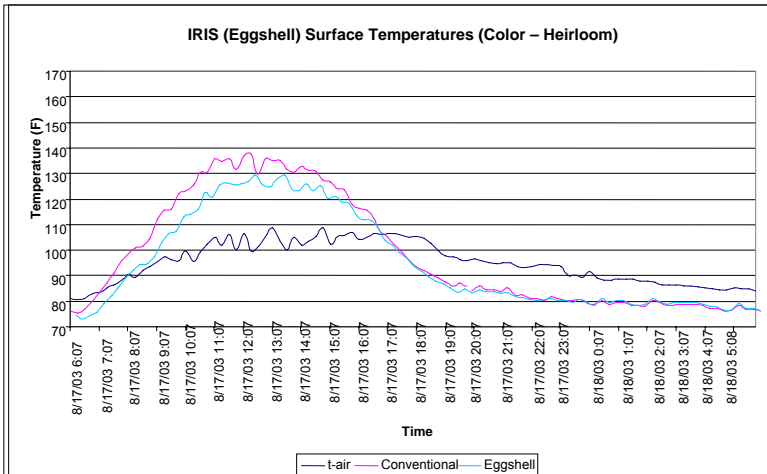


Figure 4: IRIS Eggshell Coating Surface Temperatures

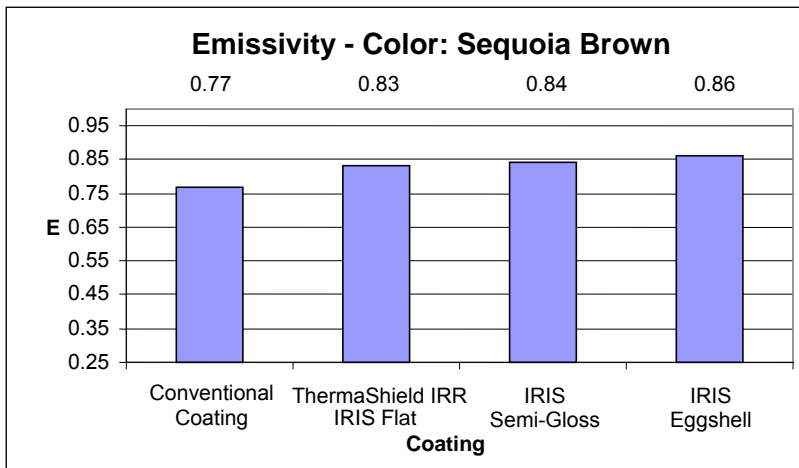
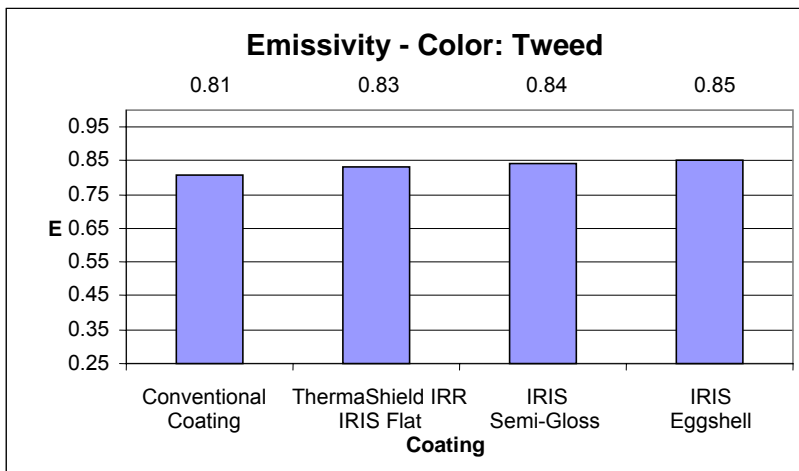
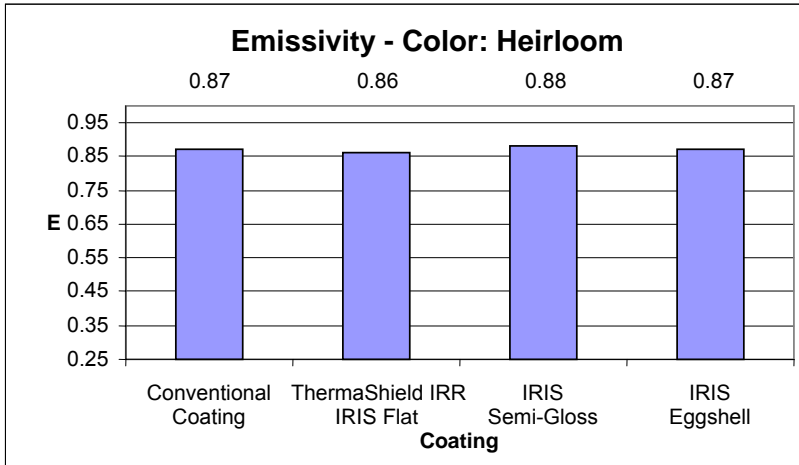


Figure 5: Emissivity values of Conventional & IRIS Coatings.

1.5 Conclusions:

The IRIS Technologies, coating technology depressed surface temperature as compared to conventional coatings in all cases. However, the most dramatic results were discovered to be across the color and not across coating categories. The Heirloom color represented the lowest surface temperature depression of 3-5°F, the Tweed color represented a modest depression of 6-8°F, and the Sequoia Brown represented the greatest depression of between 9-11°F less than the conventional painted panels. Of the coating types the IRIS coating performed slightly better in all color combinations. The relative normal emissivity values (0.8 to 0.9) for all the IRIS Technologies, coatings suggest that their surface temperature depression is not a result of long-wave radiation loss. Our findings suggest that the IRIS Technologies, coating have the greatest surface temperature benefits on the darker the surface color.

2.0 References

1. Cook, J., and H. Bryan, "Climate, Comfort and Health," ASU Report to Central Phoenix/East Valley Light Rail Transit, May 2002.