Parametric Wind Force Analysis on a Residential Roof Mounted Photovoltaic Panel

Objective: Investigate the wind generated forces via CFD on a photovoltaic (PV) panel mounted on concrete tile residential roof.

Modeling Assumptions and Details: The PV system consists of 4 modules that are aligned edge-to-edge to create an overall panel having dimensions of 130" x 62" x 2". The panel is mounted to the roof with 8 mounting brackets. The mounting brackets are 4" wide and are attached along the bottom and top edges of the PV Panel. Given this geometry, the panel was idealized as a 2-D structure.

The PV Panel was mounted mid-way up on an inclined roof (10, 18 and 30 degree slopes were investigated). Mounting details and roof geometry are provided within the body of this report.

The PV Panel height was investigated at 3.25, 4.5 and 6.0" heights. At the lowest level (3.25"), the rear opening underneath the aluminum rails and the concrete roof was blocked. At the 4.5 and 6.0" heights, the PV Panel was open on both ends.

A total of nine conditions were investigated and their configurations are summarized in the table given on the next page.

The wind load for this simulation was a constant 100 MPH air stream.

Steady-state conditions were assumed.

CFD software used for this analysis work was CFdesign V7.0. Details on this software can be found at www.CFdesign.com.

Conclusions: The table given on page 3 documents the PV panel lift and drag forces under the various conditions. The forces are for the complete 130x62" panel. Negative lift is pushing the panel into the roof. Positive drag is pushing the panel up the roof. In other words, lift is perpendicular to the PV panel while drag is parallel to the panel.

Worst case lift and drag conditions were noted for the 3.25" Height / 18 Degree panel at 963 and 79 lbf. In all cases, when the PV panel is blocked, high lift forces are created. In general, when air can flow unimpeded underneath the panel, the forces are roughly a third and lower.

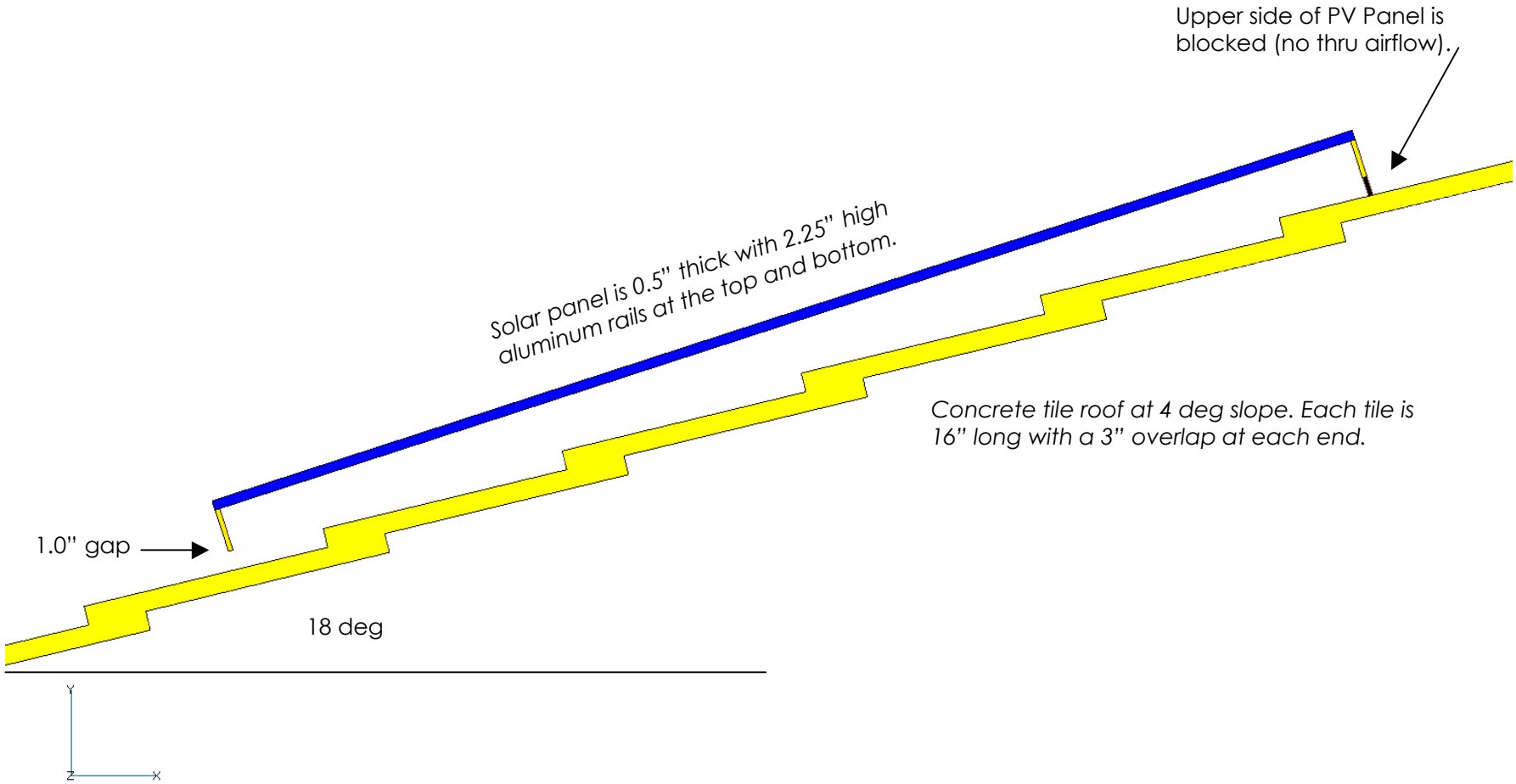
A wind gust analysis is also included in the Appendix. This leeward side gust analysis indicates that PV Panel uplift from vortex shedding on the eave of the roof will not be a problem.

In conclusion, PV panel blockage should be avoided whenever possible. When air can flow underneath the panel, the greatest amount of lift found was 330 lbf as compared to 963 lbf for the blocked panel.

E: *George.Laird@PredictiveEngineering.com*

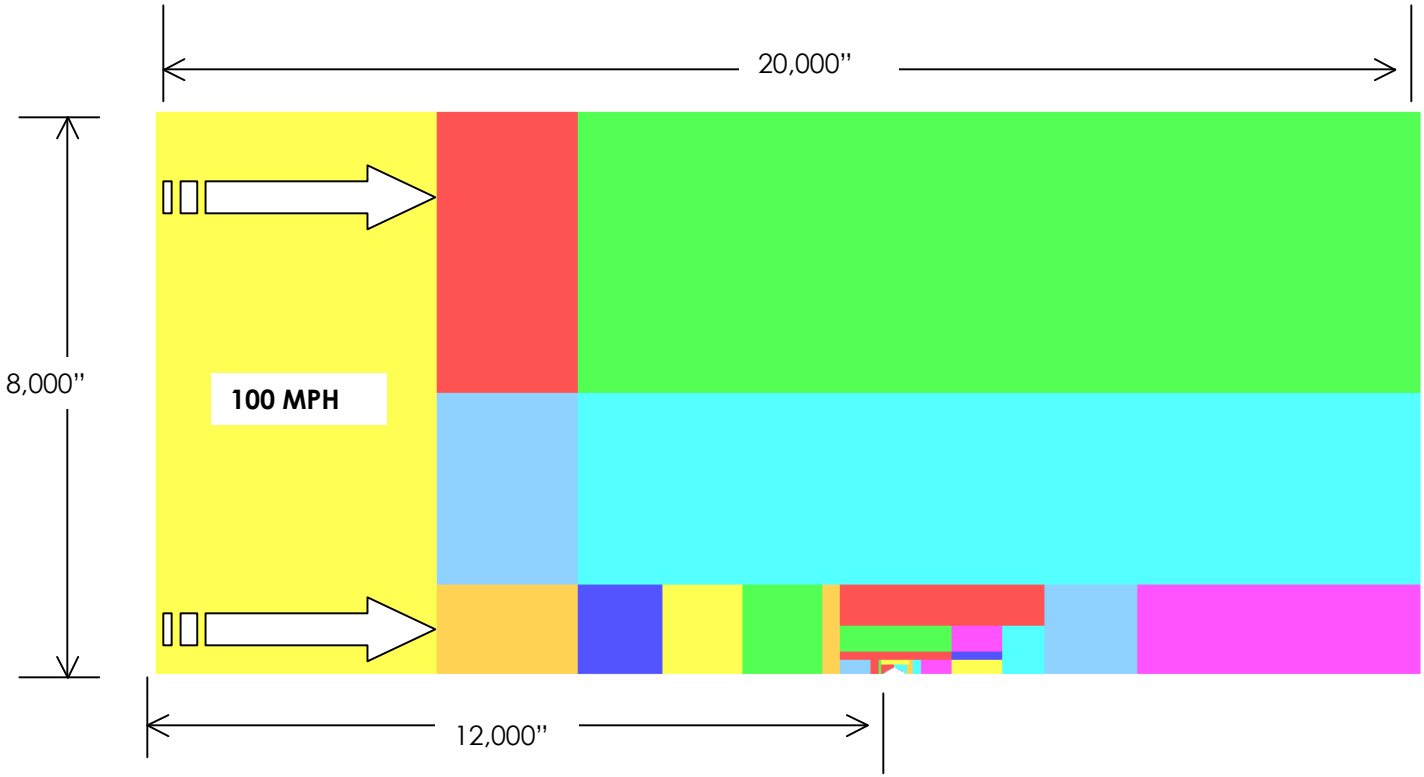
CFD Modeling Details of Roof-Only Photovoltaic Panel on Concrete Tile Roof

E: *George.Laird@PredictiveEngineering.com*



The PV panel is assumed to be 0.5" thick and mounted on top of two aluminum rails having a height of 2.25". The PV panel has a 1" gap between the rails and the concrete tiles at the front and blocked at the other end. No airflow is assumed to occur underneath the panel but it is allow to equilibrate with the external pressure field. In the other simulations (4.5" and 6.0" Heights) the PV Panel is unblocked.

E: *George.Laird@PredictiveEngineering.com*



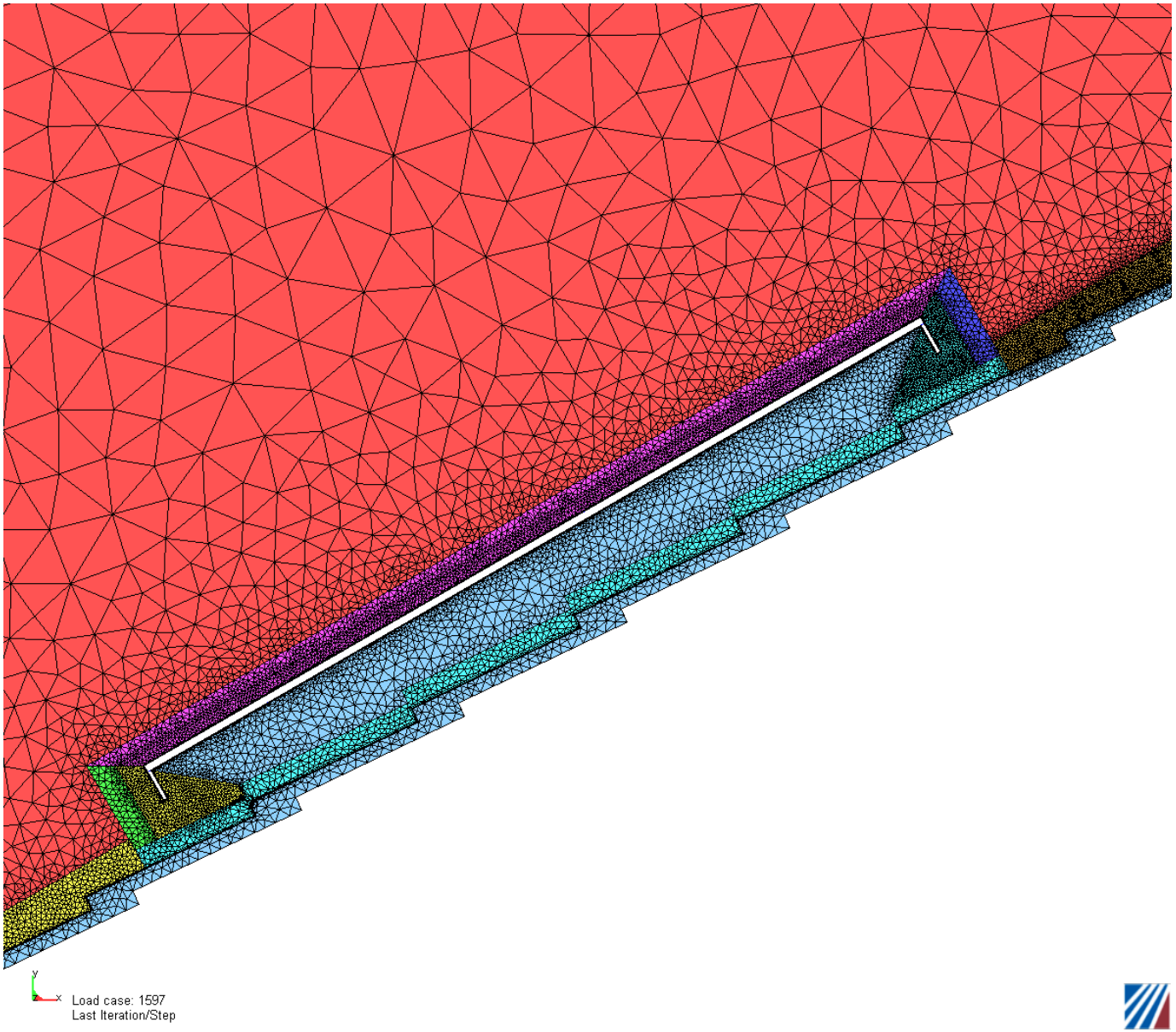
Load case: 1597
Last Iteration/Step

The 2-D house structure was then embedded into a virtual air tunnel and segmented into discrete areas to allow the finite element grid to be graded from very fine near the PV panel to very coarse at the ends of the air domain.

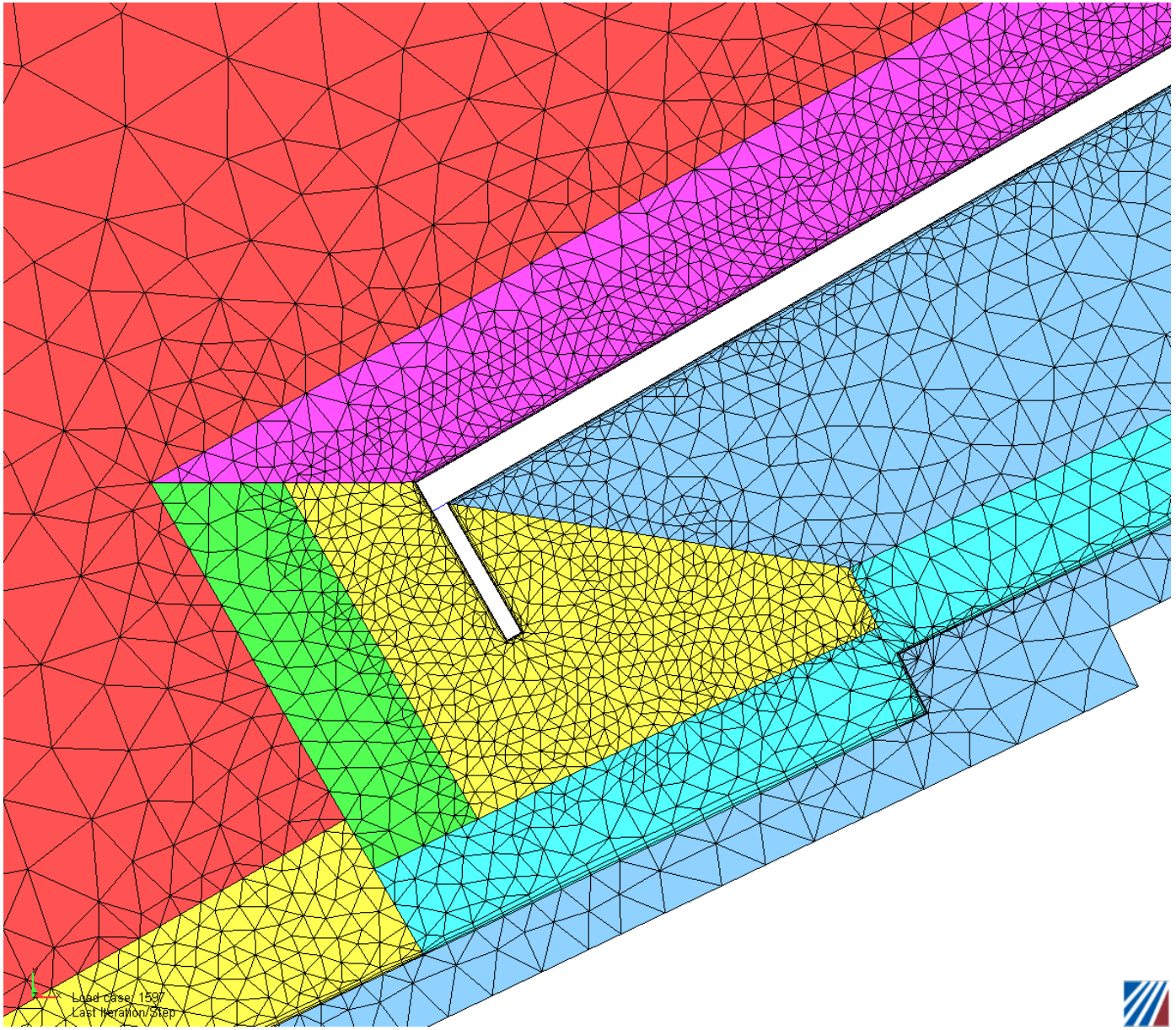
E: *George.Laird@PredictiveEngineering.com*

CFD Modeling Mesh Details

E: *George.Laird@PredictiveEngineering.com*



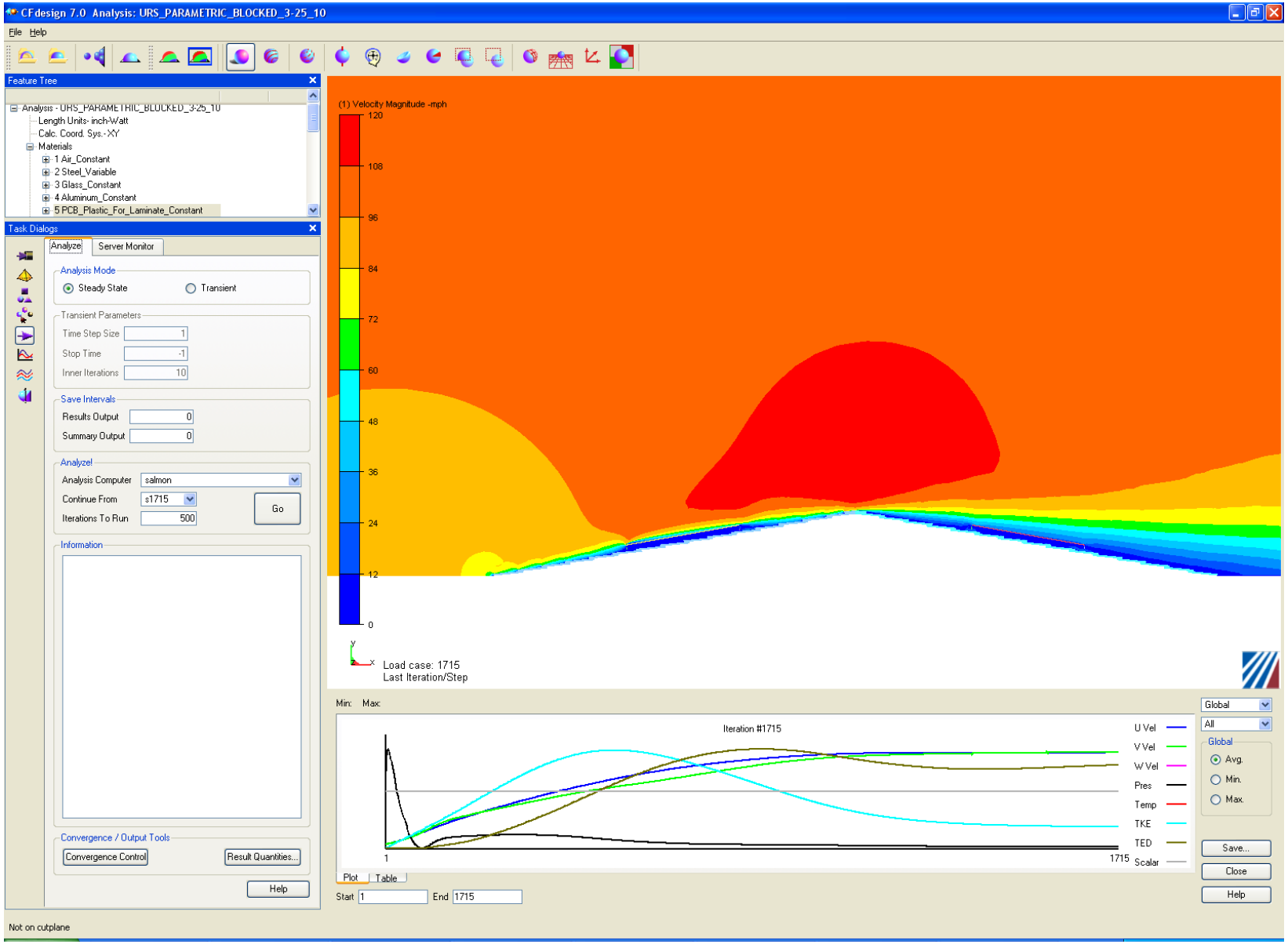
E: *George.Laird@PredictiveEngineering.com*



E: *George.Laird@PredictiveEngineering.com*

CFD Results at 100 MPH: 3.25” Height / 10 Degree Roof Pitch

E: *George.Laird@PredictiveEngineering.com*



The run time graphic is shown above. Steady-state convergence was achieved after about 1400 iterations. The model run was continued since the run was performed overnight and ran unattended until it had finished.

E: *George.Laird@PredictiveEngineering.com*