Generating Reduced Thermal Models with SimCenter3D Space System Thermal

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# AbstRact

With our modern computing resources, thermal engineers will opt to develop complex models rather than spend time simplifying the geometry to reduce runtime. This works well to obtain detailed component temperatures at the unit level, but causes issues when a number of those units must be integrated in a system-level analysis. Runtime increases exponentially with the element count, and even though SimCenter3D/TMG has tools to mitigate that, conductive-radiative models with hundreds of thousands of elements will result in models with tens of millions of radiative conductances and may take days to solve.

To be able to perform system-level analyses within a reasonable timeframe, unit suppliers will provide their prime contractor with Reduced Thermal Models. Those models have an element count that is a fraction of the original model, but will yield temperatures that are very close to the original complete model. The primary objective of the RTM is to provide accurate temperatures for the external geometry and the interface with the system-level model. A looser accuracy requirement will typically be defined for the internal components – the objective of the RTM is not to predict detailed temperature inside the unit, but rather to represent accurately its contribution to the overall system.

Over the last few years, the research and papers on this topic have focused on automatically generating lumped thermal nodes based on temperature maps, and computing the equivalent conductances based on temperatures from the detailed model. This approach will often provide acceptable results, but has some drawbacks such as a limited accuracy for variable boundary conditions.

This paper shows two other methods to generate a reduced thermal model. The first one makes use of the physical properties of the thermal model rather than the temperatures, with the intent of making the resulting model more robust to transient boundary conditions. The second method is optimization-based, and allows generating an extremely reduced model with minimal effort. A representative thermal model is used to test those two methods, as well as the more traditional temperature-based approach. Meaningful values from the reduced models are compared to results from the full model, and the accuracy is tested across several operating scenarios representative of a real satellite operation.