MULTIPHYSICS OPTIMIZATION AND APPLICATIONS OF SURROGATE THERMAL MODELS USING SIMCENTER 3D SPACE SYSTEMS THERMAL, SIMCENTER NASTRAN AND HEEDS

Zouya Zarei, Loic Bourgeois, Jean-François Labrecque-Piedboeuf, Chris Blake, Christian Semler
MAYA HTT, Montreal, Canada

PROPOSED SESSION: "INTERDISCIPLINARY"

ABSTRACT

Thermal engineers leverage Thermal Math Models to design spacecraft systems, understand the response of such systems to the harsh environment of space, and perform design trade studies to choose amongst various alternatives. However, even conservatively sized models with only a few thousand nodes/elements can be lengthy to simulate, considering long transient maneuvers and mission cycles.

Surrogate models or response-surface models approximate the actual response of a design to the chosen design parameters, using simpler basis functions. Such models can be evaluated very fast, as they are essentially an algebraic computation of the response on the surface fit. They can be used to understand the sensitivity of the design to the different parameters, and save a tremendous amount of time when optimizing the design.

This presentation will elaborate on the usage of surrogate models in comparison to other reduced model techniques, and will demonstrate how a multiphysics surrogate model can be created from a Simcenter 3D Space Systems Thermal (SST) and Simcenter Nastran model using the multi-disciplinary optimization software called HEEDS. This combination of software suite uniquely chained within one environment allows close collaboration between the thermal and the structural analysts to reach simultaneously multiple objectives.

The thermal model of a microsatellite is created in Simcenter 3D SST, with the key design parameters (e.g. radiator dimensions, optical properties, unit mounting resistances) represented as expressions. These expressions are recognized automatically by HEEDS and used to drive a Response Surface DOE study, where the design space is sampled using a Latin Hypercube space filling algorithm. From a thermal point of view, maximum, minimum, or average temperatures, and heat loads can be extracted from Simcenter 3D SST group reports. At the same time, automatic mapping of the temperatures onto a detailed structural model for each iteration allows quick evaluation of the deformation and eccentricity of the optical assembly that needs to stay within specific bounds to meet optical requirements.

Several response-surface model types may be selected in HEEDS, including Kriging and Radial Basis Functions. The response-surface model can then be exported in various languages, such as

C#, Python, Matlab for further processing, or Modelica for reuse in model-based systems simulation programs.

This demonstrated automatic thermo-elastic/multiphysics evaluation combining a dedicated thermal solver for space applications (SST), a widely accepted structural solver in the industry (Simcenter Nastran) as well as the multi-disciplinary optimization software (HEEDS), all within one environment, is unique and saves a considerable amount of time for the design and validation of new spacecraft.