Collaborative Design and Analysis of Electro-Optical Sensors

The Aerospace Corporation has worked with Comet Solutions, Inc. to develop a Simulation Driven Engineering (SDE) software tool that enables Electro-Optical (EO) sensors to be designed and analyzed in an integrated and collaborative manner across engineering discipline boundaries. This brochure illustrates the use of the SDE environment for integrated Structural/Thermal/Optical Performance (STOP) analysis - the analysis of optical performance impacts arising from structural deformations to an opto-mechanical system that are caused by quasi-static changes in instrument thermal environment.

The STOP process described here is an example. Once developed by discipline experts, complex interdisciplinary analyses can be rerun for parametric studies or optimization purposes from Comet’s Project Dashboard.

Features of the current SDE software-enabled EO sensor design environment:

- The SDE software is configured to work with the CAD and CAE tools that discipline engineers already use to do their work: PRO/Engineer® or SolidWorks® (mechanical CAD), Abaqus® or MSC NASTRAN® (structures), Thermal Desktop® (thermal), SigFit (structural to optical conversion), CodeV® (optics), Excel®, and more.
- Design and analysis data for all disciplines is captured in a common data model that anyone can access through the SDE software interface. This allows ready access to all analysis and key performance data.
- Project data is efficiently captured and organized in the Comet™ project. All analysis data and design variations are captured. Version control is enforced to ensure consistency of design between disciplines.
- Interactive problem solving and design reviews are conducted within the Comet environment without the need for PowerPoint snapshots of design status. Quantitative visualization of CAD/CAE results across discipline boundaries and in a single eye span facilitates discovery and troubleshooting of interdisciplinary design issues.
- Model predictions can be easily compared to test results within Comet’s SDE environment.

STOP analyses that typically take days to weeks can now be run in a single day.

Design cycle time is reduced by factors of 2X or more and most data handoff errors are eliminated by capturing expertise in Comet simulation templates.
Step 1: Process starts with a single integrated CAD model for the optical system with tags applied by discipline engineers to parts and subassemblies that will be used by them for downstream analysis.

Step 2 (structures): The parts of the CAD model of structural interest are FEM meshed for subsequent analysis using rules that are iteratively developed by the structures engineer and captured in the Comet environment.

Step 3: The meshed thermal model is imported into Thermal Desktop for analysis of temperature distributions subject to boundary conditions and material properties specified by the thermal engineer and captured in the Comet environment. The temperature field is automatically mapped to the fine structures mesh.

Step 4: The meshed structures model and the temperature field produced by Thermal Desktop are imported into Abaqus for calculation of structural deformations subject to boundary conditions and material properties specified by the structures engineer and captured in the Comet. Lens mount contact stresses are modeled accurately, as shown to the right.

Step 5: Temperature fields from Thermal Desktop and structural deformations from Abaqus are imported into SigFit. SigFit outputs a modified optical design model that represents structural deformations as rigid body component motions plus Zernike polynomial deformations to the optical surfaces. Zernike polynomials are also used to represent wavefront errors introduced by thermal gradients within the lenses.

Step 6: Code V uses the modified optical model output by SigFit to quantify impacts on optical performance produced by thermally-induced structural deformations and by changes in the refractive indices. An exit pupil wavefront error map is shown at left and a Modulation Transfer Function plot at right.