

# Integrated Analysis of Thermal/Structural/Optical Systems

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## ABSTRACT

Productivity bottlenecks for integrated thermal, structural, and optical design activities were identified and systematically eliminated, making possible automated exchange of design information between different engineering specialties.

The problems with prior approaches are summarized, then the implementation of the corresponding solutions is documented. Although the goal of this project was the automated evaluation of coupled thermal/optical/structural designs, significant process improvements were achieved for subset activities such as stand-alone thermal, thermal/structural, and structural/optical design analysis.

## INTRODUCTION: PROBLEM STATEMENT

Structural, thermal, and optical engineers typically work independently of each other using unrelated tools, models, and methods. Without the ability to rapidly exchange design data and predicted performance, and therefore to influence each other's efforts, the prior state-of-the-art for the design of advanced optical systems was inadequate: it has henceforth resisted attempts to achieve the ideals of concurrent engineering. Limited success has been achieved at a very top-level (suitable for conceptual design studies), but only by approximating or neglecting the detailed design tasks that the engineering specialist must perform in later mission phases.

Without the ability to work concurrently, the disciplines of thermal control, structures, and optics levy worst-case performance requirements on each other such that each specialty can contribute to a design independently. The optical engineers dictate distortion limits to the structural engineer, who then dictates limits on temperatures and gradients to the thermal engineer. Requirements are derived, then flowed down. The thermal and structural engineers blindly obey these limits under all operational conditions, thereby satisfying the optical performance requirements.

That approach results in a stack-up of margins and inevitably to over-design, to the point of rendering advanced mis-

sions such as NASA's Next Generation Space Telescope (NGST), with its cryogenic large aperture optics, difficult to achieve without an integrated design approach. For example, temperature gradients in a mirror support structure are inconsequential as long as the required optical performance is achieved, yet derived limits on such gradients often become a design driver for thermal control specialists.

## DESIGN PROCESS INTEGRATION

This paper describes the first step, which was to achieve tighter and smarter communication pathways between existing tools such as ORA's CODE V® optical analyzer, the MSC/NASTRAN® structural analyzer, and C&R's SINDA/FLUINT and Thermal Desktop®. Once this was achieved, the ability to externally drive the design towards an optimum was implemented and tested, as described in Reference 1.

Previous innovations by the development team had eliminated many of the stumbling blocks that had stymied earlier attempts to achieve a tight integration between thermal control, structures, and optics. These prior advances include a finite element-compatible and CAD compatible thermal radiation analyzer (Ref 2), thermal tools compatible with structural programs (Ref 3), optimizing thermal/fluid solvers (Ref 4), and integrated structures/optics design.

The theme of "intelligent integration without sacrificing the tools or methods of each specialty" was carried forward into the idea of providing system-level design optimization tools. In other words, the goal of this development was not merely an integrated tool suite, but also one that can automatically explore the design space to find an optimal design that meets required optical performance under all structural load cases and thermal environments.

As will be seen, however, the end product (OptiOpt™, for "optimized opto-mechanical design") does not have to be applied in its entirety in order to achieve significant improvements over prior design practices. Rather, improvements to the underlying thermal and optical codes and the generation of general purpose model conversion and mapping schemes are useful in and of themselves. In

# Integrated Analysis Of Thermal Structural Optical Systems

**Yongtian Wang**



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The novel begins with Richard Papen, a bright but troubled young man, arriving at Hampden College. Richard is immediately drawn to the group of students who call themselves the Classics Club. The club is led by Henry Winter, a brilliant and charismatic young man. Henry is obsessed with Greek mythology and philosophy, and he quickly draws Richard into his world. The other members of the Classics Club are equally as fascinating. Bunny Corcoran is a wealthy and spoiled young man who is always looking for a good time. Charles Tavis is a quiet and reserved young man who is deeply in love with Henry. Camilla Macaulay is a beautiful and intelligent young woman who is drawn to the power and danger of the Classics Club. The students are all deeply in love with Morrow, and they are willing to do anything to please him. Morrow is a complex and mysterious figure, and he seems to be manipulating the students for his own purposes. As the students become more involved with Morrow, they begin to commit increasingly dangerous acts.

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