



**C&R TECHNOLOGIES**

**Integrated Analysis of  
Thermal/Structural/Optical Systems  
(OptiOpt™ Part 1)**

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# Acknowledgements

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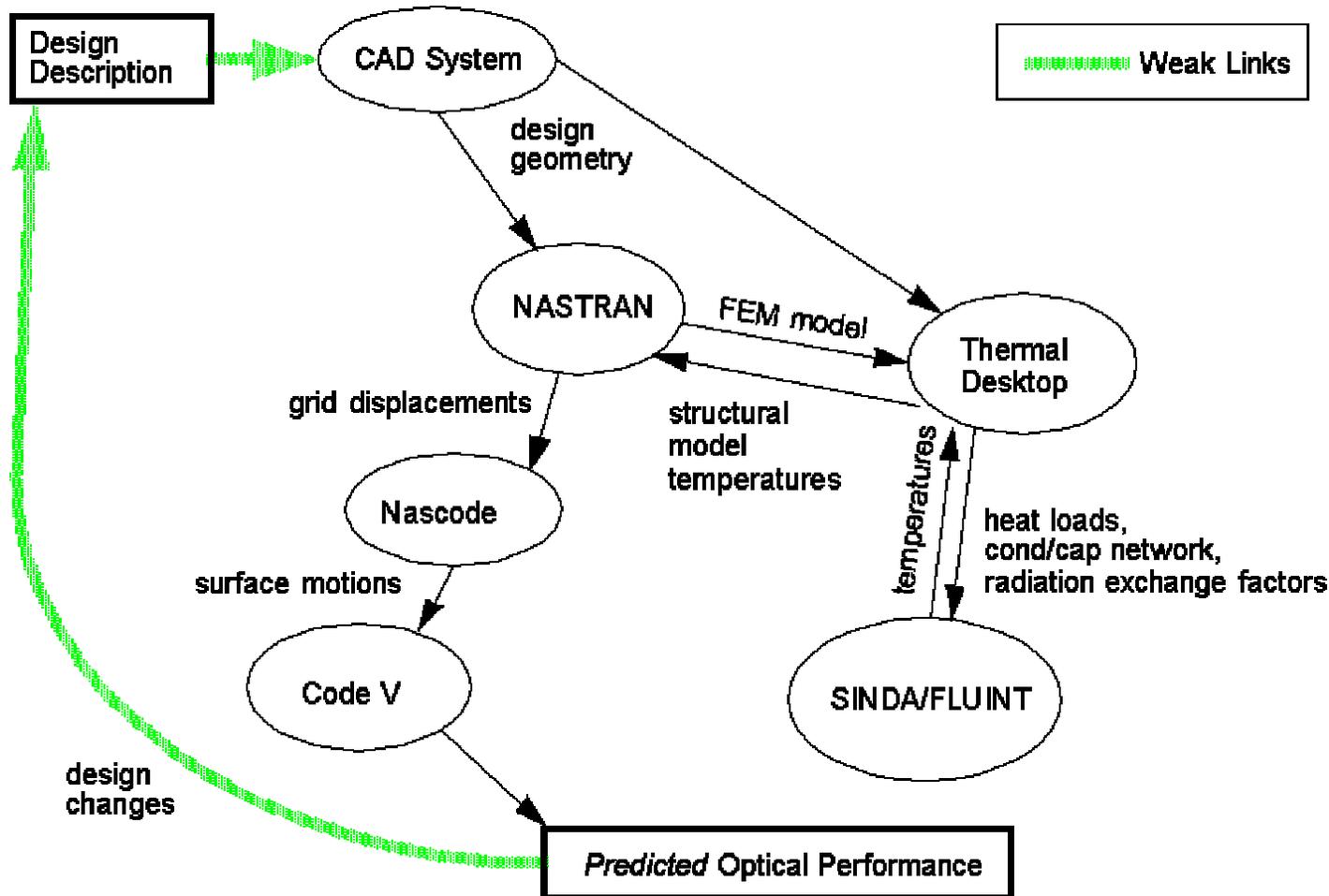
# The Problem

- Thermal, structural, and optical engineers work independently using unrelated tools
  - ➔ Structural requirements derived from optical ones: *maximum deflections*
  - ➔ Thermal requirements derived from structural ones: *maximum temperature gradients*
- Worst-cases are stacked up: **overdesign**
- One approach: a single tool that replaces industry standards like NASTRAN, SINDA
  - ➔ Limited acceptance by specialists
  - ➔ appropriate for conceptual design only





# OptiOpt™ Improvements (Part 1)





# Elimination of Analysis Bottlenecks

- Thermal (Thermal Desktop®)
  - ➔ CAD-based and FEM-compatible analyzer
  - ➔ Fully parameterized with API for automated tasking
- Thermal to Structural (MSC/NASTRAN®)
  - ➔ Temperature mapping to related (one to one) or *independent* structural model
- Structural to Optical (Code V®)
  - ➔ Deflections mapped to independent optical performance model

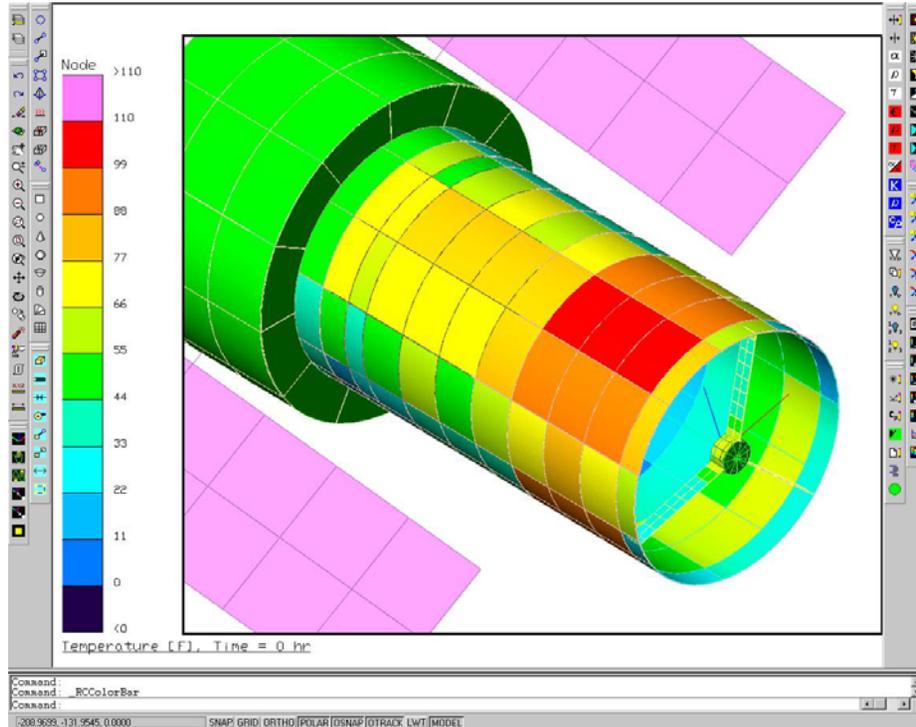


# Significant Improvements

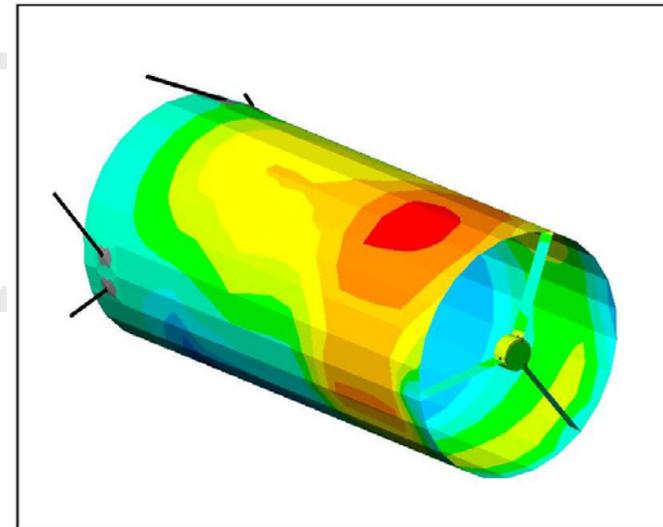
- Thermal/structural
  - ↳ Analysis integration for non-optical applications
  - ↳ Automated and accurate results mapping
    - ↳ no need to use structural model as thermal model
    - ↳ no need to use one-to-one mapping (FEM -> network)
    - ↳ no need to use structural model for interpolation
    - ↳ *thermal and structural models can be created independently*
    - ↳ thermal model can use any mix of FD, FEM
- Thermal-only
- Structural/optical



# Automatic Temperature Mapping

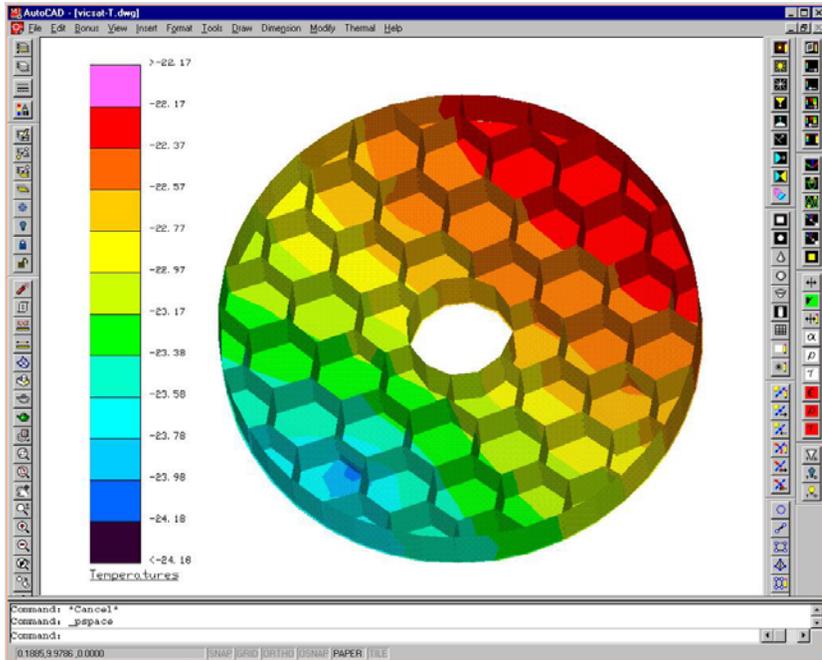


Thermal Desktop results automatically mapped to more detailed NASTRAN FEM model





# Thermal & Structural Models Developed Independently

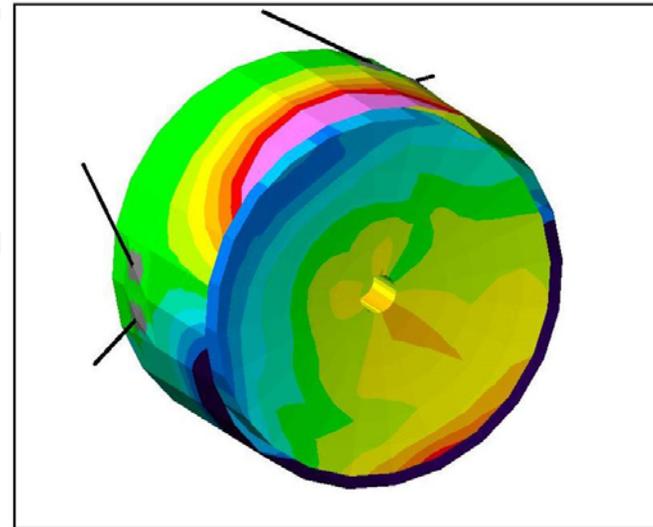


Thermal model consists of both  
FD and FEM components.

- FD: solar arrays and body
- FEM: mirrors and metering structures.

The “trick:”

- import FEM node *locations*,  
not *model*
- use *thermal* model as basis:  
greatest accuracy





# Significant Improvements

- Thermal/structural
- Thermal-only
  - ➔ Parametric thermal analysis
  - ➔ Dynamic Mode:
    - ➔ Use SINDA/FLUINT as a “scripting language”
    - ➔ Access SINDA/FLUINT Advanced Design Modules
      - ➔ Optimization
      - ➔ Automated correlation to test data
      - ➔ Automated worst-case scenario seeking
      - ➔ Statistical design: reliability assessments
- Structural/optical



# Parametric Thermal Modeling

The image shows a software interface for parametric thermal modeling. It features three overlapping dialog boxes:

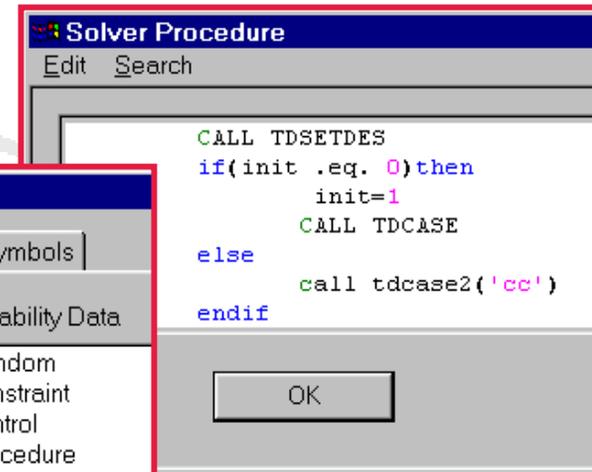
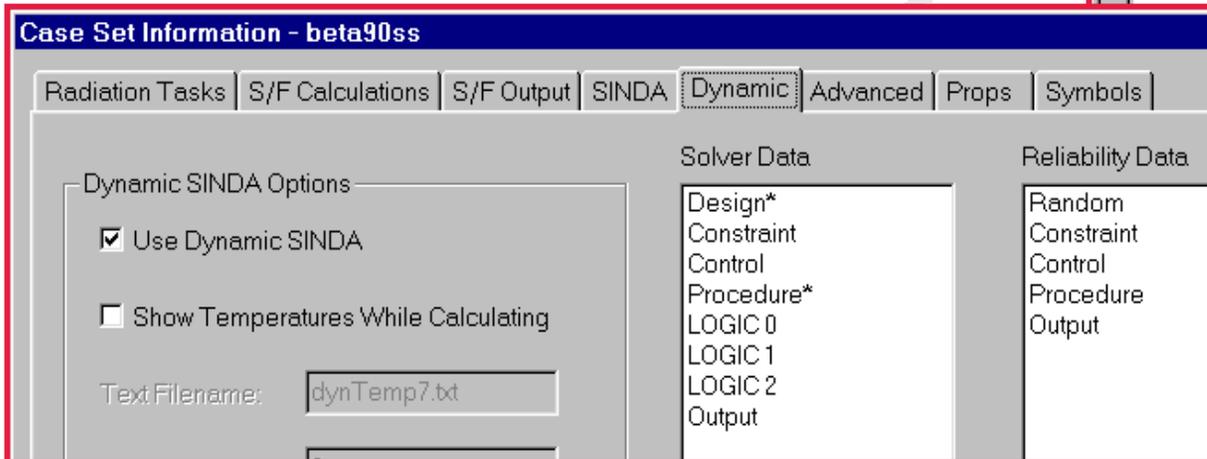
- Symbol Editor:** A window for defining symbols. It has a "New Symbol Name:" field, an "Add" button, and a table of existing symbols. The table lists symbols like pfD, Pffpu, pfH, pfKA, pi, PMbody, PMthick, PMthruG, rtd, shD, shellCP, shellK, shellLEN, shellThk, shellwall, SMshellT, SMthick, SMthruG, smZ, spiderT, and Tdetect. The "name, evaluated result, expression:" header is above the table. Buttons for "Edit" and "Delete" are on the right.
- Thermal Model Data:** A dialog box with tabs for "Subdivision", "Numbering", "Radiation", "Cond/Cap", "Contact", "Insulation", and "Surface". The "Cond/Cap" tab is active. It includes a checked "Generate cond/cap data" option, a "Cond submodel:" dropdown set to "SHELL", and input fields for "Material:" (invar), "Thickness:" (0.02), and "Material Orientation CS name:". There are also "Not Used" sections for other materials and separations.
- Expression Editor:** A dialog box for defining expressions. It has a "Select units for:" dropdown set to "Length" and two unit selection dropdowns (one set to "in"). A "Symbol Manager..." button is present. Below is a list box containing the symbol "shellThk".

Blue arrows indicate the flow of data: one arrow points from the "shellThk" entry in the Symbol Editor to the "shellThk" entry in the Expression Editor, and another arrow points from the "Thickness:" field in the Thermal Model Data dialog to the "Expression Editor" dialog.



# Thermal Desktop “Dynamic Mode”

- Radiation or conductance capacitance calculations can be invoked “on the fly” from within SINDA/FLUINT
- Full access to SINDA Advanced Design Modules from within TD Case Set Manager





# The GMM/TMM Distinction is Gone!

- GMM: RadCAD, TRASYS, TSS, ESARAD, etc.
- TMM: SINDA, ESATAN, etc.
- “Dynamic Mode” means TMM and GMM linked
- Some of the new possibilities:
  - ➔ Size a heat pipe radiator
  - ➔ Simulate louvers and variable- $\varepsilon$  coatings directly
  - ➔ Find the worst-case  $\beta$  angle and solar panel position
  - ➔ Automatically correlate optical properties to test



# Significant Improvements

- Thermal/structural
- Thermal-only
- Structural/optical
  - ➔ Conversion utility from NASTRAN deflections to Code V optical surface displacements



# Conclusions

- Significant improvements were made in the underlying codes useful for subset analyses:
  - ➔ thermal/structural
  - ➔ thermal only
  - ➔ structural/optical
- Such tight integration of otherwise independent models enables the next step:
  - ➔ *automatically* (“hands off”) searching for an optimal thermal/structural/optical design