C&R TECHNOLOGIES

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

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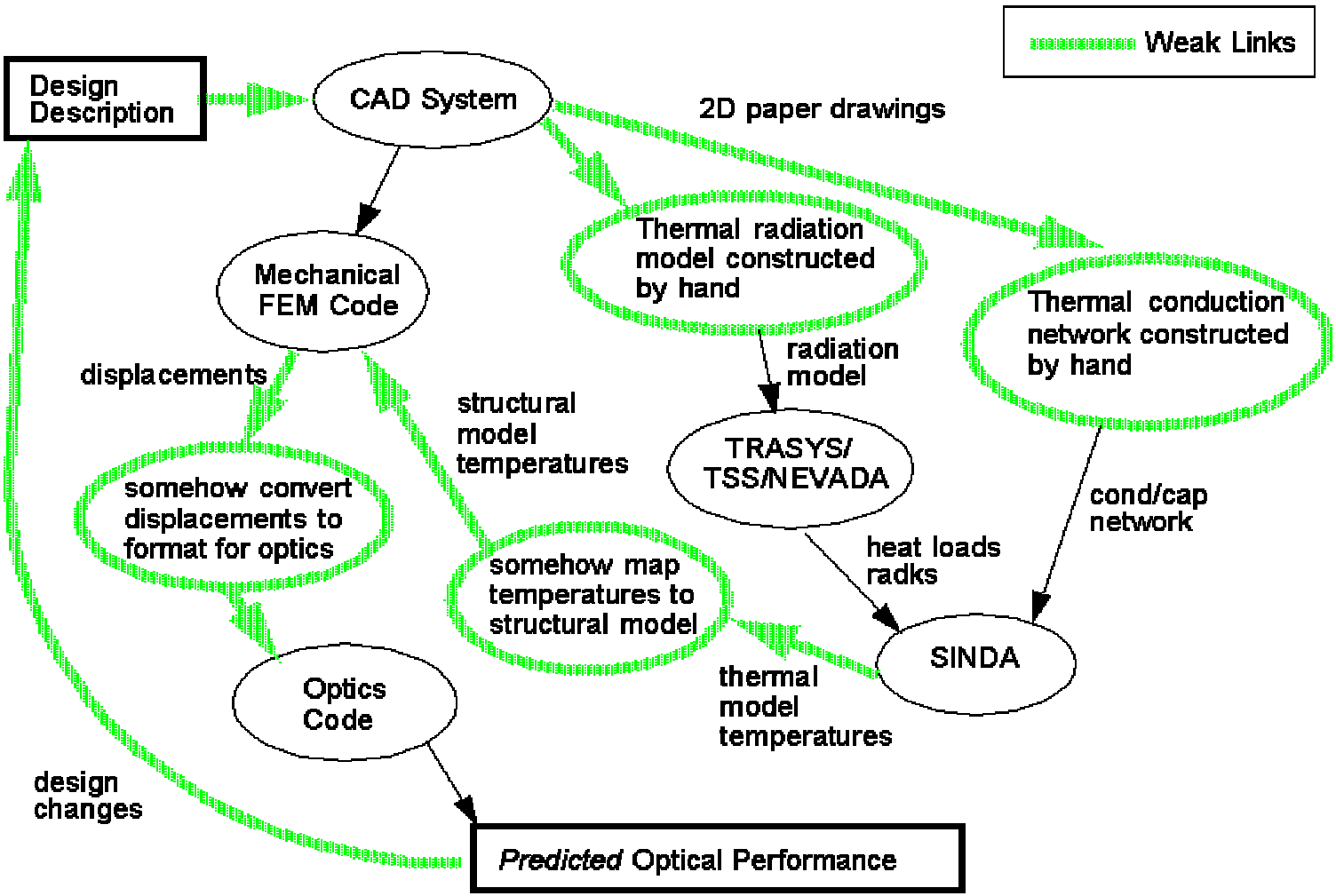
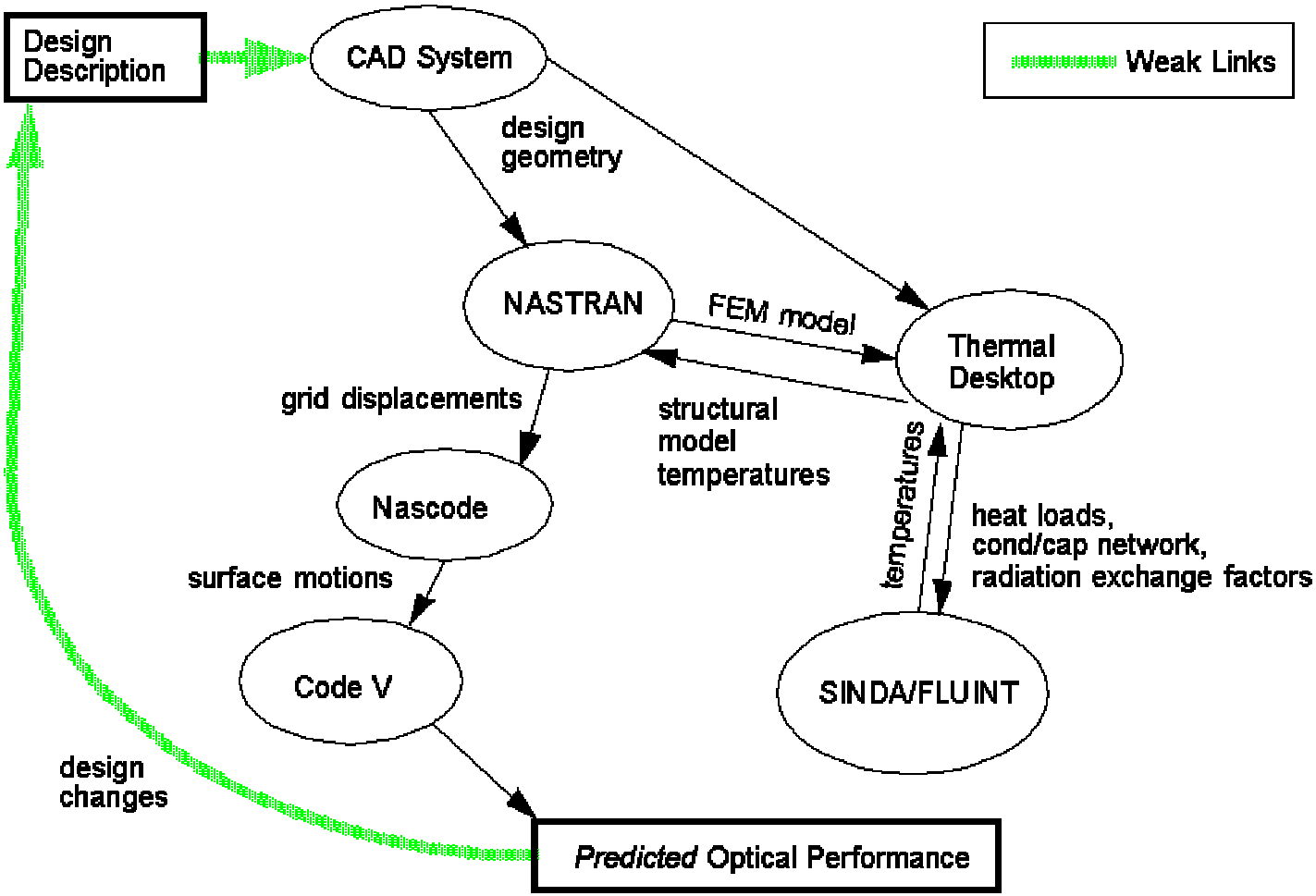
The Problem

- 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

Prior State of Art



OptiOpt™ Improvements (Part 1)



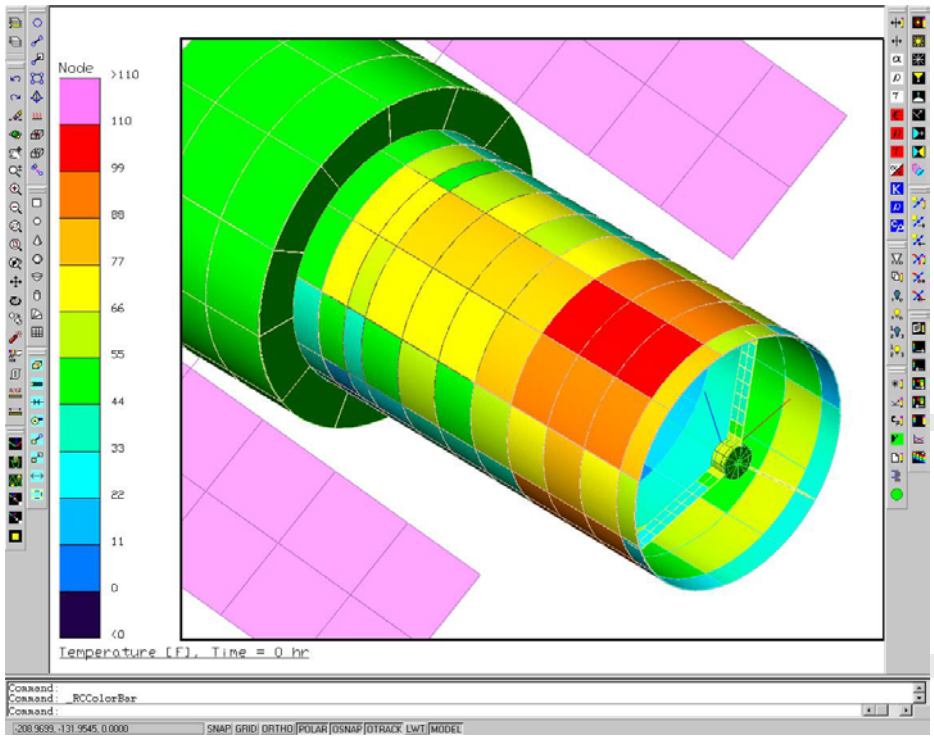
Elimination of Analysis Bottlenecks

- 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

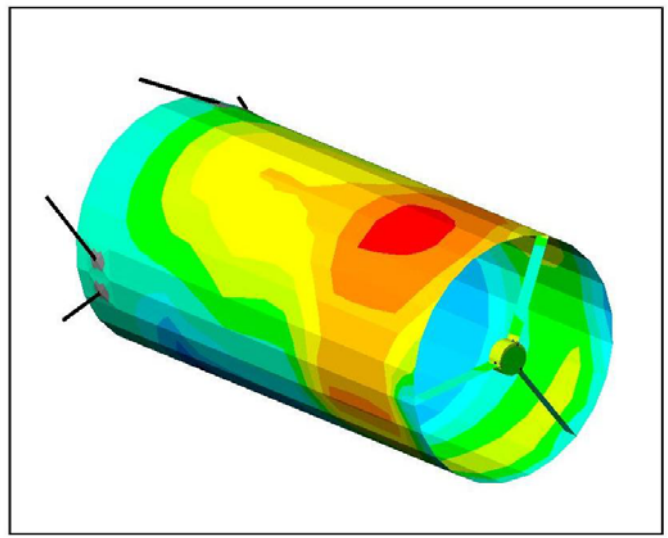
Significant Improvements

- 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

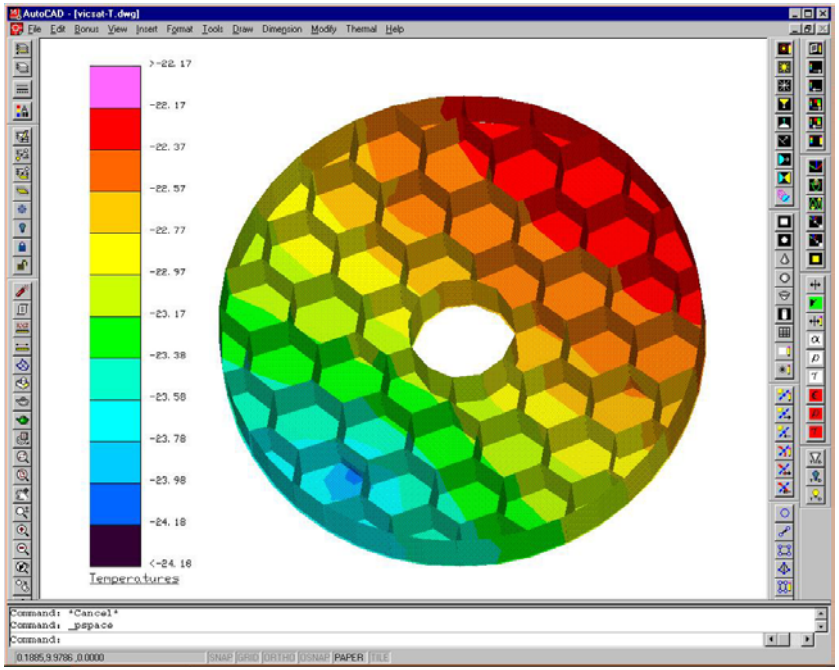
Automatic Temperature Mapping



Thermal Desktop results automatically mapped to more detailed NASTRAN FEM model

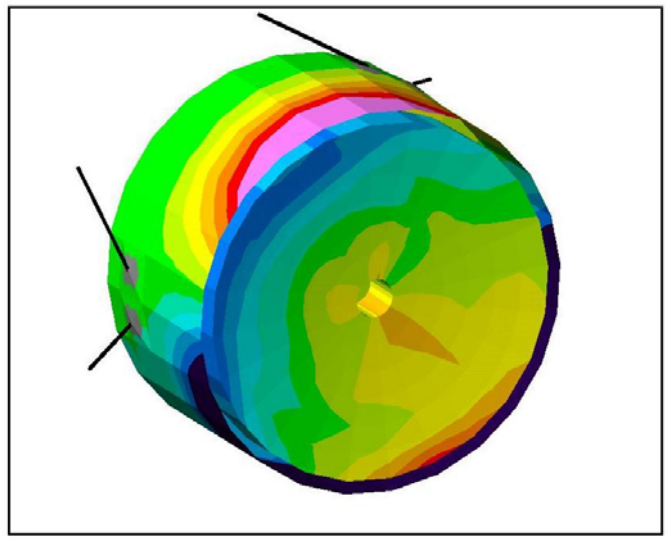


Thermal & Structural Models Developed Independently



Thermal model consists of both FD and FEM components.

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



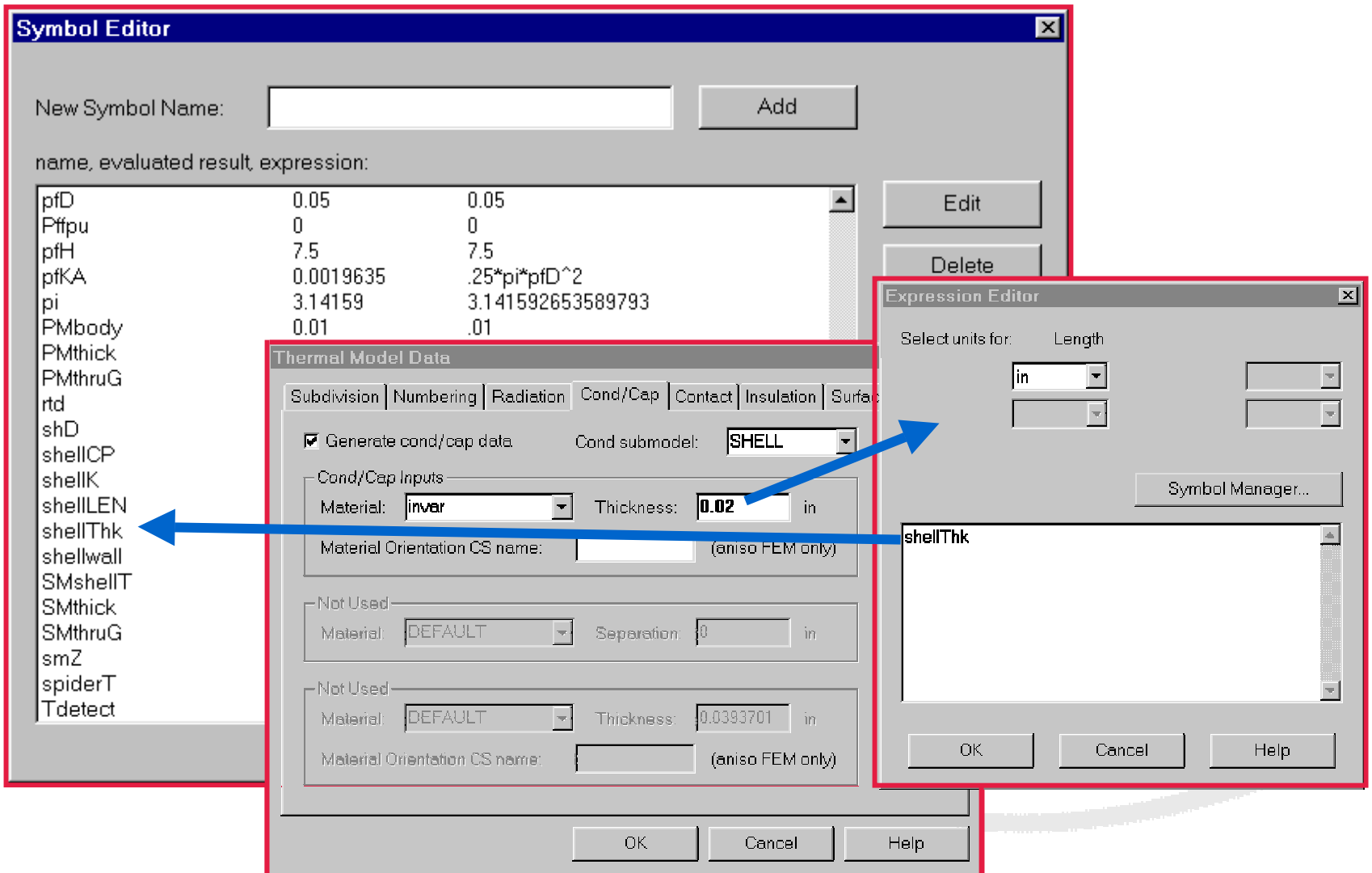
The "trick:"

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

Significant Improvements

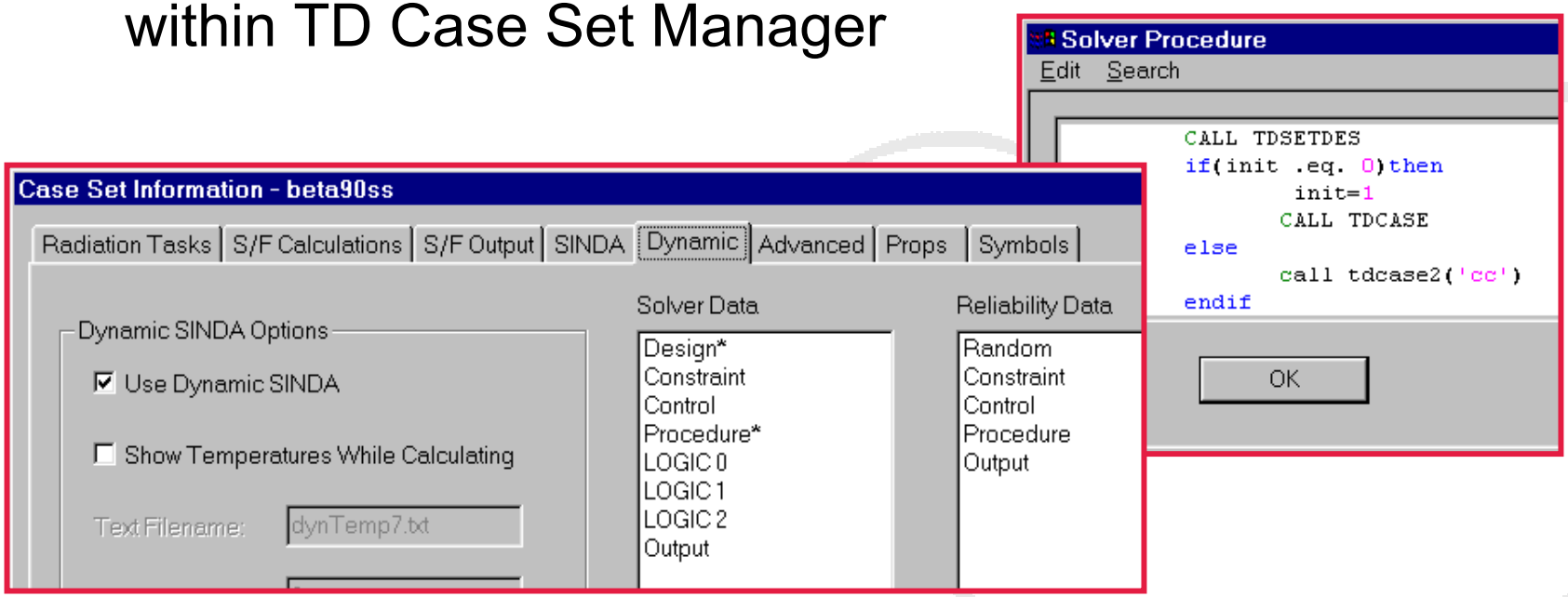
- Thermal/structural
- Thermal-only
  - Parametric thermal analysis
  - Dynamic Mode:
    - Use SINDA/FLUINT as a “scripting language”
    - Access SINDA/FLUINT Advanced Design Modules
      - Optimization
      - Automated correlation to test data
      - Automated worst-case scenario seeking
     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

Parametric Thermal Modeling



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-ε coatings directly
  - Find the worst-case β 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