Engineering Thermal Analysis and Design System

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Goals of the Analysis System

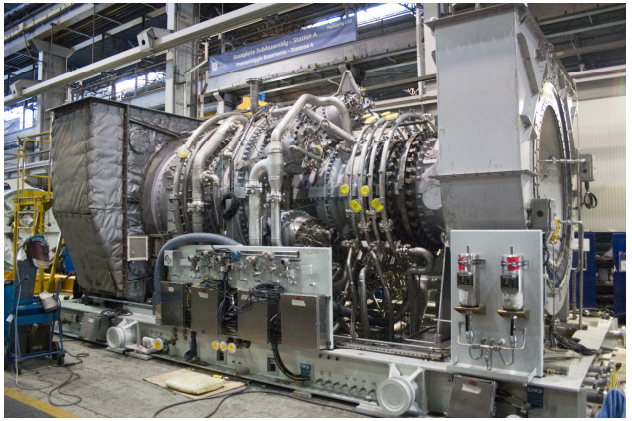
High Level Objectives

- Improved Model Build Cycle Time
- Reduced Model Update Cycle Time
- Reduction in Errors
- Reduced Training Time
- Repeatable Process that is Best Practice and Design Practice Compatible

Business Impact

Aviation

Oil & Gas

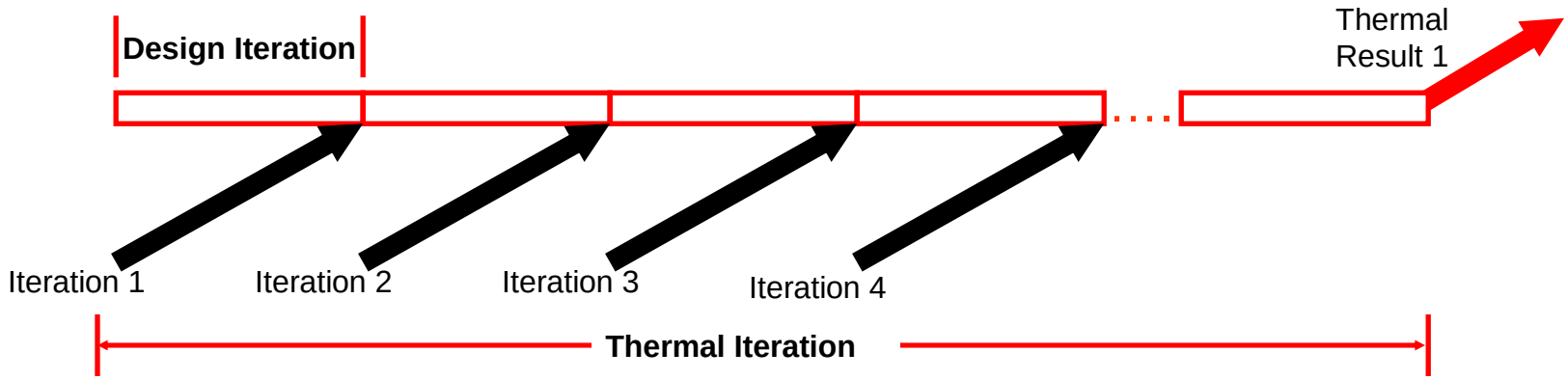


Energy GT

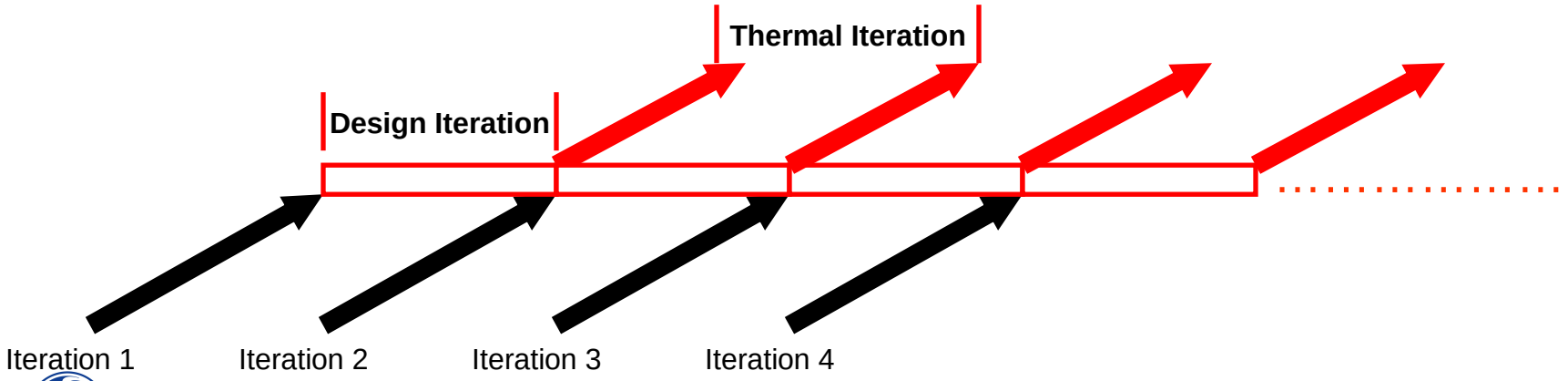
Energy ST

Design and Analysis

Legacy Process



Improved Process



Thermal Modeling Process

Process Map

CTQ's

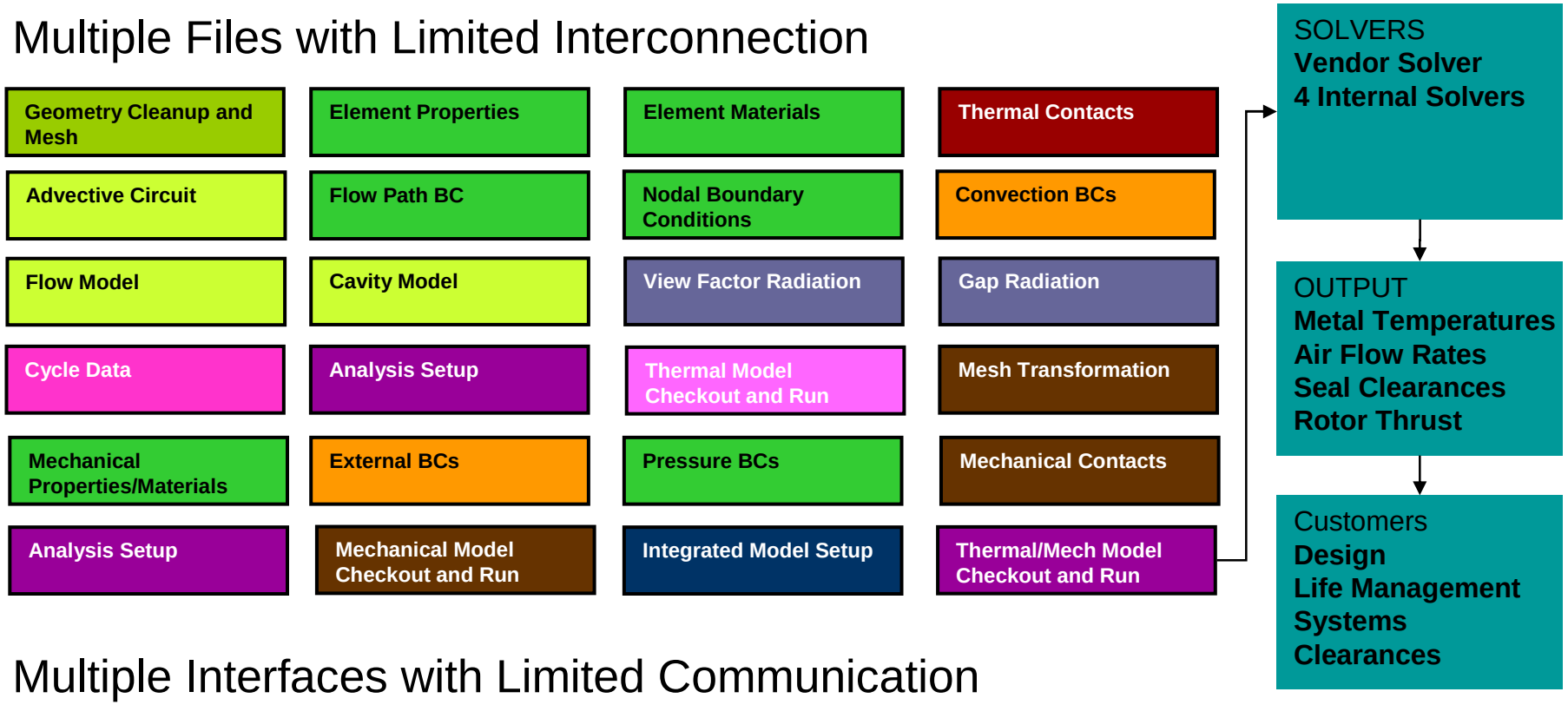
- 10x reduction in cycle time
- Ability to react quickly to geometry changes
- Physics based modeling consistent with DPs
- Reduced user and modeling errors ➔ Get the model right the first time
- Smooth transition from Legacy

Prior System Limitations:

- Unconnected large data sets (16 files)
- Multiple tools in different applications
- Time consuming process for Heat Transfer model update

Legacy Modeling Interface

Multiple Files with Limited Interconnection



Multiple Interfaces with Limited Communication

Vendor Pre | Internal Pre | Text Editors | Error Checker | Scripts

Improved Modeling Interface

Integrated Database with Process Flow

Geometry Cleanup and Mesh	Element Properties	Element Materials	Thermal Contacts
Advective Circuit	Flow Path BC	Nodal Boundary Conditions	Convection BCs
Flow Model	Cavity Model	View Factor Radiation	Gap Radiation
Cycle Data	Analysis Setup	Thermal Model Checkout and Run	Mesh Transformation
Mechanical Properties/Materials	External BCs	Pressure BCs	Mechanical Contacts
Analysis Setup	Mechanical Model Checkout and Run	Integrated Model Setup	Thermal/Mech Model Checkout and Run

SOLVERS
Vendor Solver
4 Internal Solvers

OUTPUT
Metal Temperatures
Air Flow Rates
Seal Clearances
Rotor Thrust

Customers
Design
Life Management
Systems
Clearances

Single Interface

Hypermesh

Why Hypermesh?

Robust Core Functionality

- Very strong Meshing and Mesh Morphing capability
- Very strong relational database
- Efficient at large model manipulation
- Altair technical support is outstanding

Database and Interface is very customizable

- Interface customization is in TCL/TK which is readily available and popular
- TCL/TK is scripted language which speeds up application development

Tight integration of PRE and POST processing

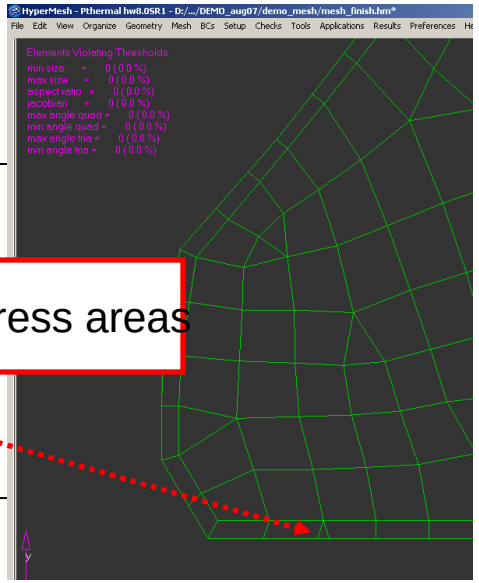
Geometry Cleanup and Meshing

Process Map

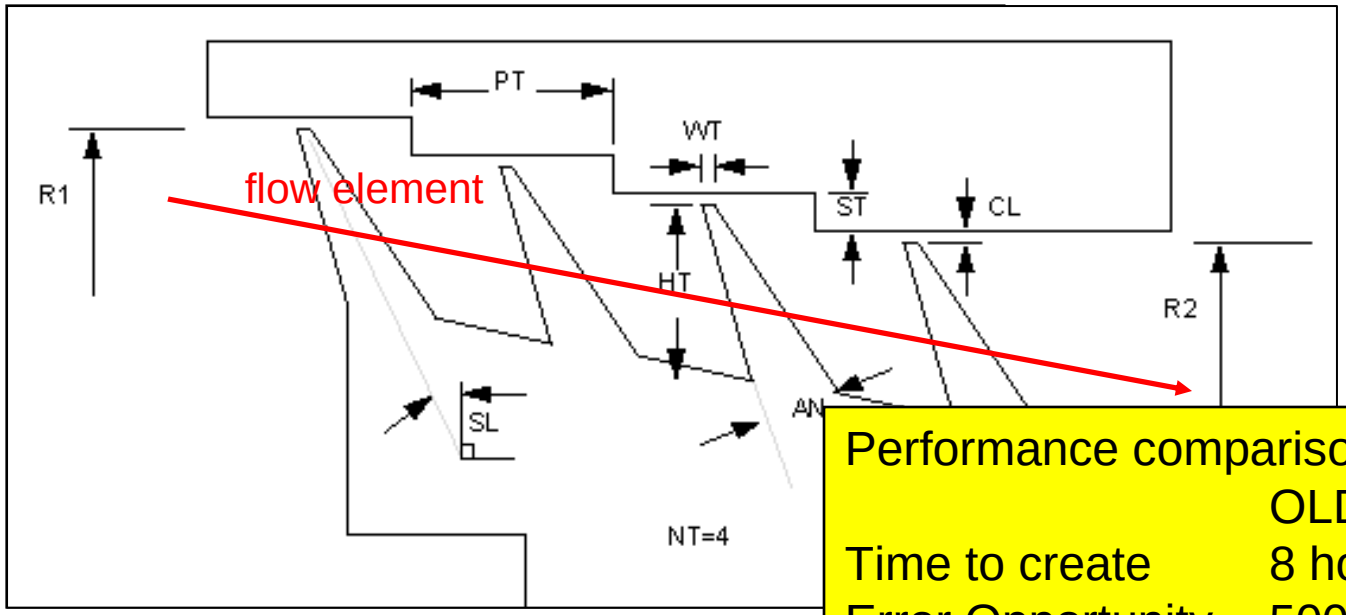
Best Practice

- For Thermal models, it is recommended to have:
  - Biot Number: Bi < 0.3
  - Fourier Number: Fo > 1.0
  - Aspect Ratio < 6
  - Enclosed Angle < 135

Control element size in high stress areas



Auto Lab Seal Creation



Performance comparison (10 Seals)		
	OLD	NEW
Time to create	8 hours	1
Error Opportunity	500	30

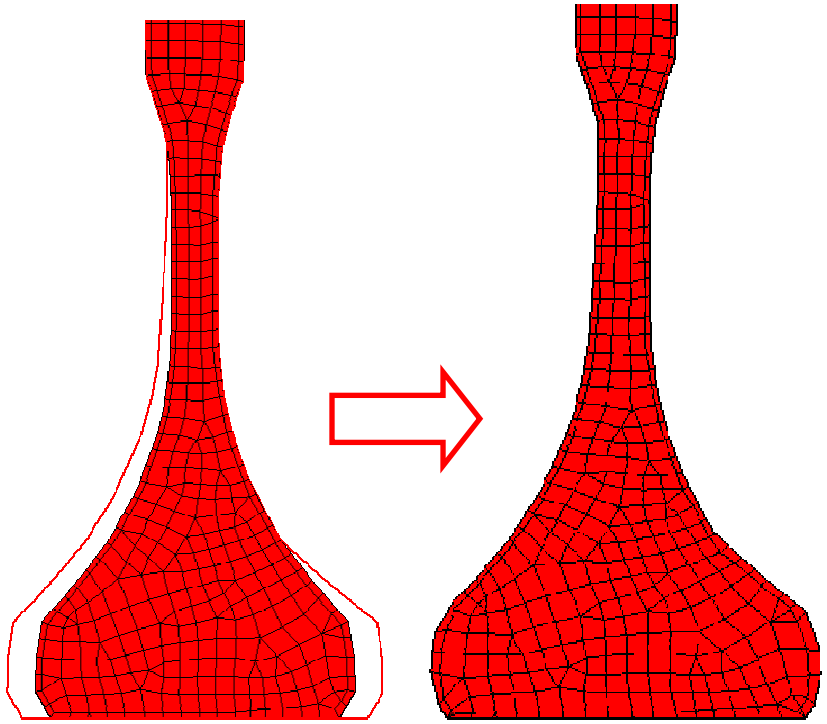
Legacy Process (Manual)

- Enter all data manually
- 1 Database and 4 text files with 50+ total entries (per seal) with several data dependencies

Improved Process (Automated)

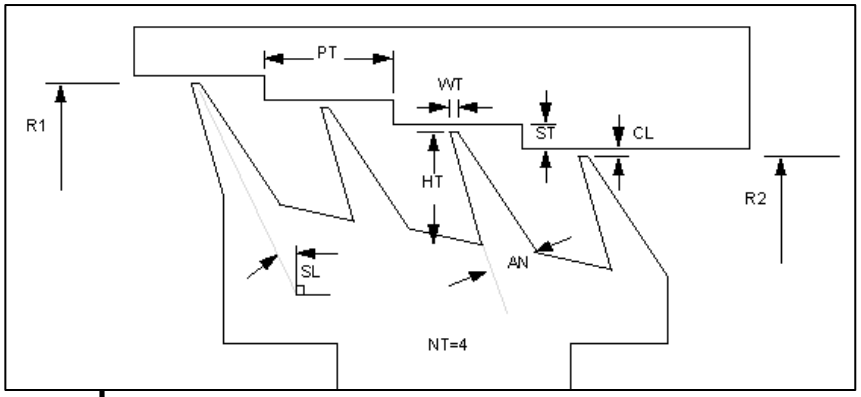
- Select a single flow element
- 1 Database with 4 entries for cold clearance for each seal with all data dependencies handled internally

Mesh Morphing



- Morphing capability is critical to the quick model update cycle time

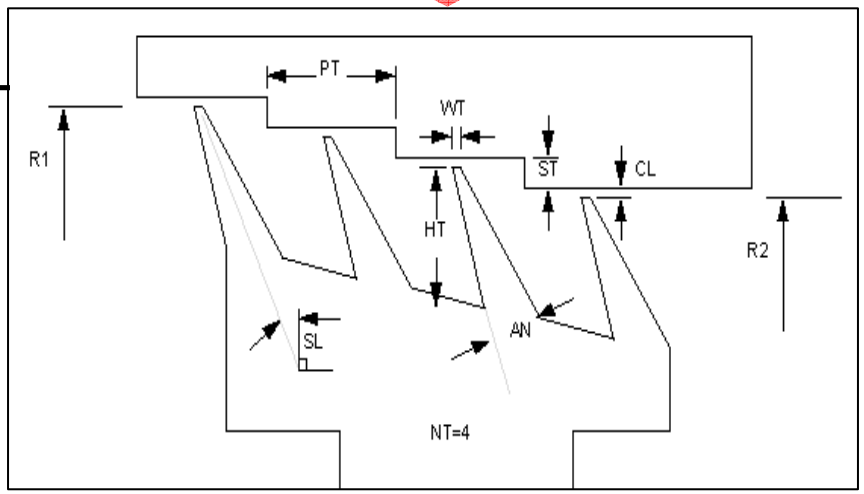
Auto Update on Morphing



Mesh Morph to New Shape

R1 = 10.0
R2 = 9.0
HT = 0.20
.
.
.

R1 = 11.0
R2 = 9.5
HT = 0.25
.
.
.



- Dimensions are calculated from node locations

Summary

Benefits

- Greatly Reduced Model Build Times
- Greatly Reduced Model Update Times
- Thermal Analysis Cycle Aligned to Design Cycle
- Greatly Increased “First Time Yield” due to Error Prevention
- Process Aligned with Best Practices

Key Enablers

- Single Relational Database with Single Entry
- Automation Tools
- Geometry Cleanup and Meshing
- Mesh Morphing with Automatic Data Updates