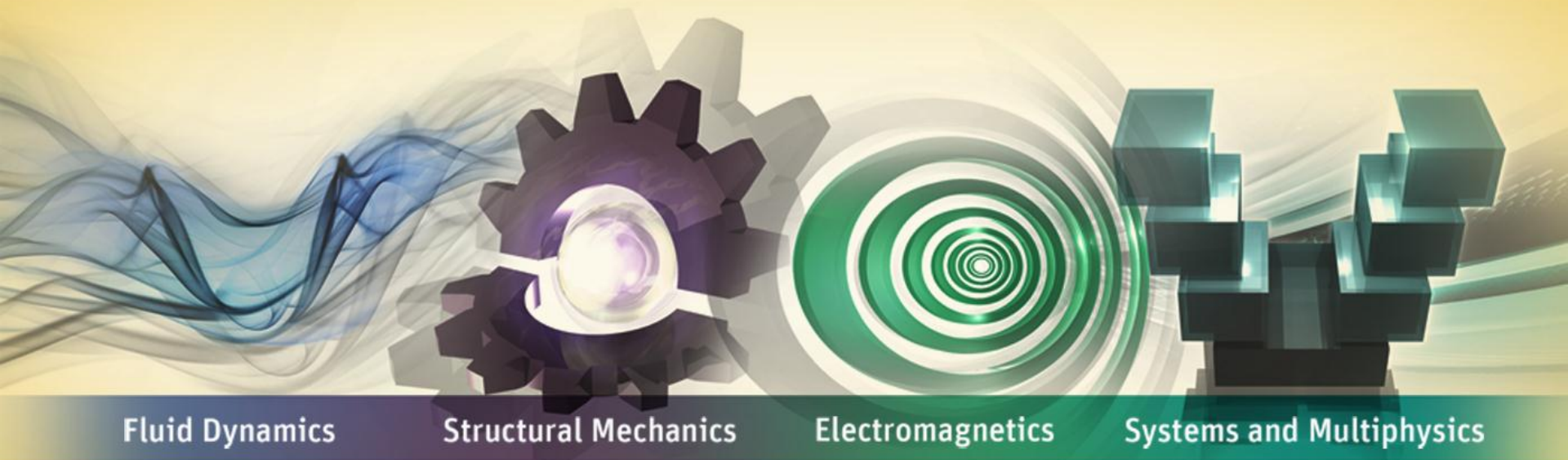
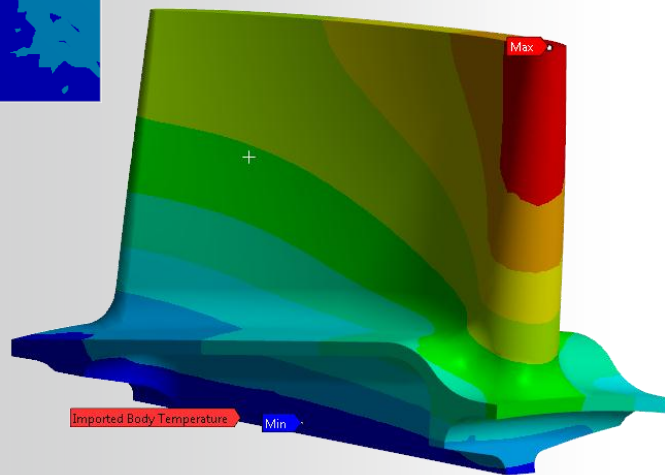


Mapping External Data on Structural Mesh



Adriano Zaffora, PhD
Application Engineer
ANSYS Italia

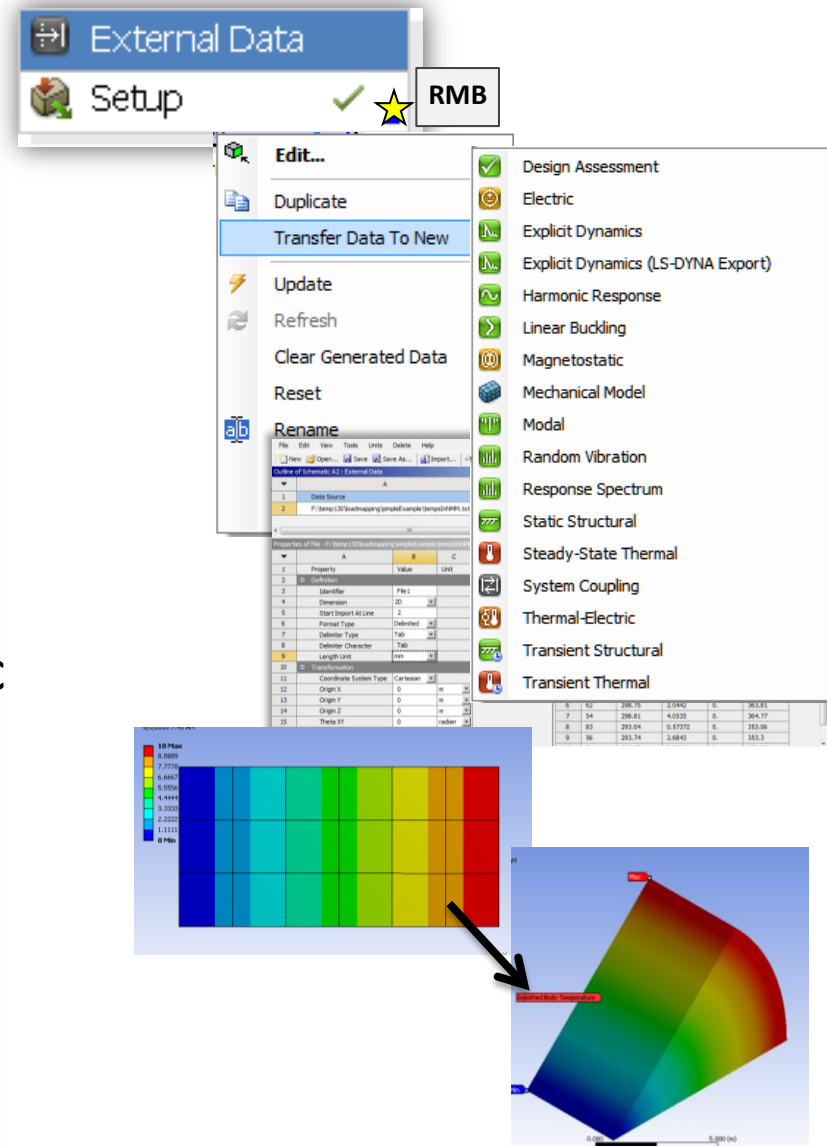


Exchange files are frequently used to transfer quantities from one simulation to another.

Efficient mapping of point cloud data is required to account for misalignment, non matching units or scaling issues.

Import Point Cloud Data

- Data can be transferred to
 - Static/Transient Structural
 - Static/Transient Thermal
 - Harmonic, Response Spectrum, PSD Analysis
 - Thermal-Electric, Magnetostatic
 - Explicit
 - Linear Buckling
 - Design Assessment, System Coupling



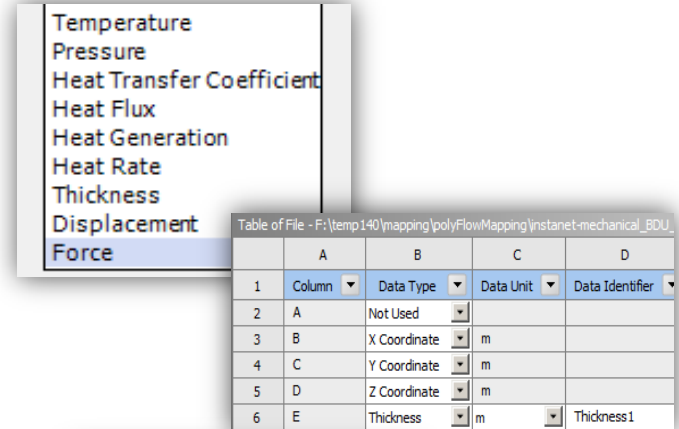
Supported Quantities

- **Loads**

- Pressure, Temperature, Convection
- Heat Flux, Heat Generation, Heat Rate
- Thickness
- Displacement, Force (R14.5)
- Velocity, Initial Stress/Strain (R15)

- **Map to**

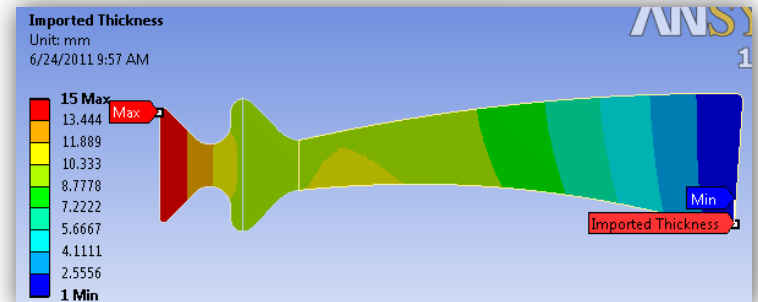
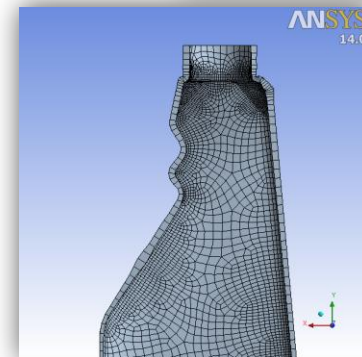
- 2D edges, 2D/3D Faces, Volumetric
- Map from 2D-2D, 3D-3D & 2D-3D



Temperature
Pressure
Heat Transfer Coefficient
Heat Flux
Heat Generation
Heat Rate
Thickness
Displacement
Force

Table of File - F:\temp\140\mapping\polyFlowMapping\instantet-mechanical_BDU_

	A	B	C	D
1	Column	Data Type	Data Unit	Data Identifier
2	A	Not Used		
3	B	X Coordinate	m	
4	C	Y Coordinate	m	
5	D	Z Coordinate	m	
6	E	Thickness	m	Thickness1



Multiple File Support

- **Multiple Files**

- Users can map multiple sets of data including multiple files to easily setup their mapping

- **External Data**

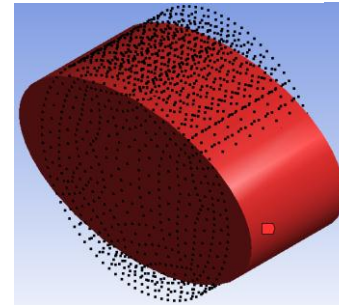
- Multi-edit to specify file formatting
- Designate 'Master File' to re-use XYZ location data (leads to much faster mapping)

Outline of Schematic A2 : External Data					
	A	B	C	D	E
1	Data Source ▾	Location	Identifier ▾	Master ▾	Description ▾
2	C:\Users\azaffora\Desktop\hs_err_pid6684.log	...	File1	<input type="checkbox"/>	
3	C:\Users\azaffora\Downloads\case_with_fix_support.txt	...	File2	<input type="checkbox"/>	
4	C:\Users\azaffora\Downloads\ANSYS1-4VNOR7.txt	...	File3	<input type="checkbox"/>	
5	C:\Users\azaffora\Downloads\case_with_snippet.txt	...	File4	<input type="checkbox"/>	
*	Click here to add a file	...			

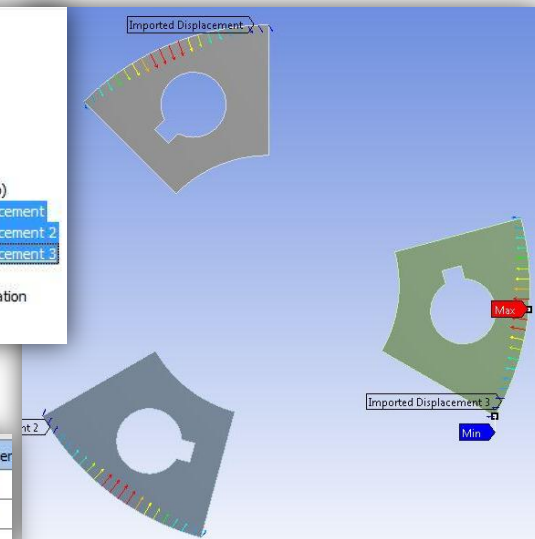
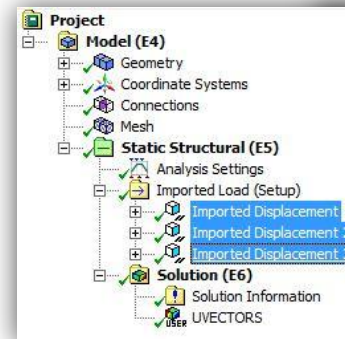
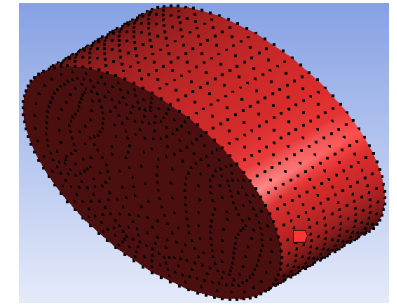
Rigid Transforms

- Source Point, **Analytical Transformation of data**
- Transforms can also be applied to **Imported vector data**
- **Use Coordinate System property** to apply data in a user-defined coordinate system.

Original source



Transformed source



Data Source	Location	Identifier
\\cantbsrv\TestBench\testsetlib\Products\MBU\Scripts\EXT_DISP_TO_MECH_001.txt	...	File 1
\\cantbsrv\TestBench\testsetlib\Products\MBU\Scripts\EXT_DISP_TO_MECH_001.txt	...	File 2
\\cantbsrv\TestBench\testsetlib\Products\MBU\Scripts\EXT_DISP_TO_MECH_001.txt	...	File 3
Click here to add a file	...	

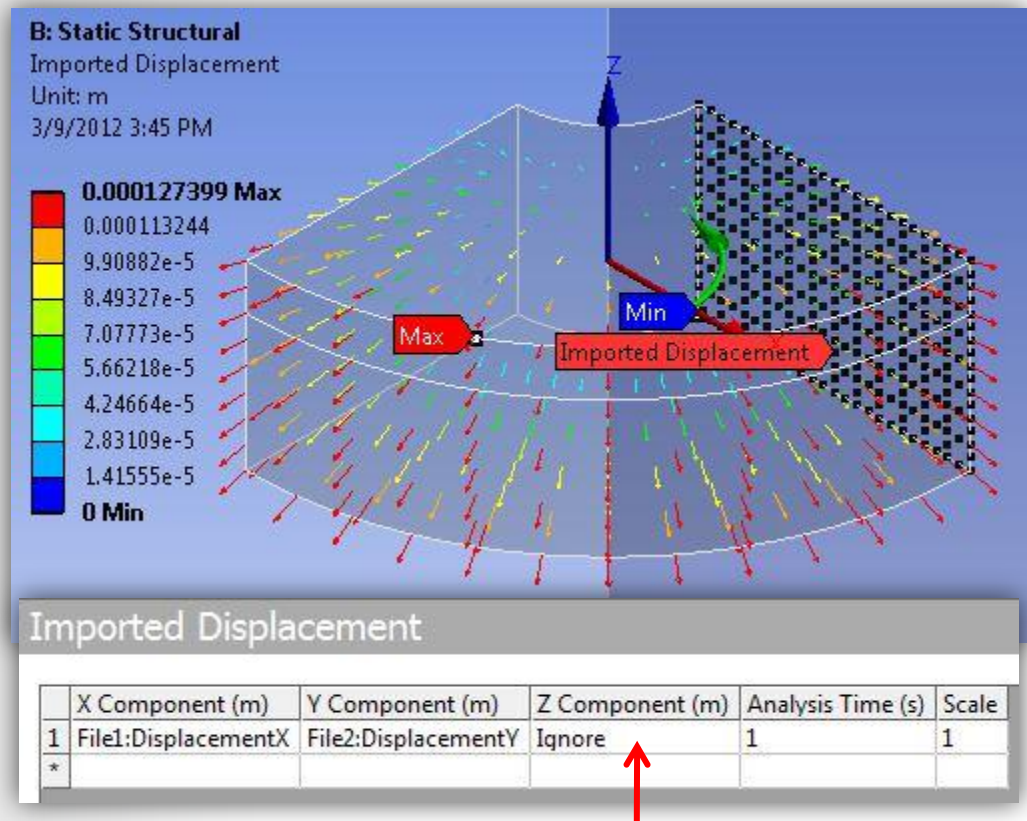
Rigid Transformation		
Origin X	0	m
Origin Y	0	m
Origin Z	0	m
Theta XY	120	degree
Theta YZ	0	degree
Theta ZX	0	degree

Rigid Transformation		
Origin X	0	m
Origin Y	0	m
Origin Z	0	m
Theta XY	240	degree
Theta YZ	0	degree
Theta ZX	0	degree

E.g. 2D-3D Mapping

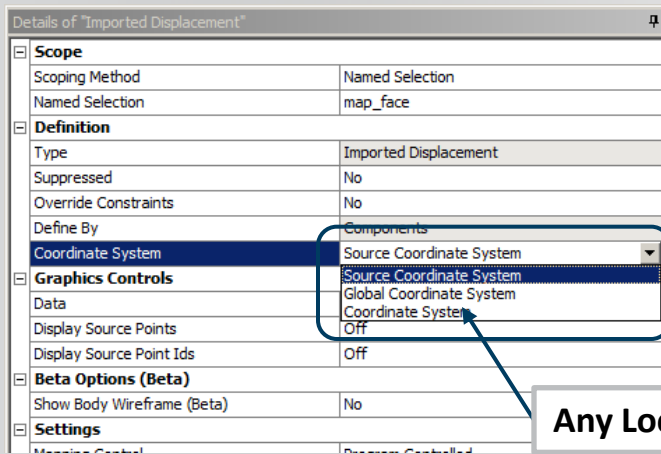
- Imported vector data is transformed for 2D-3D mapping.
- Unavailable data can be ignored in the definition.

	A	B	C
1	Property	Value	Unit
2	Definition		
3	Dimension	2D	
4	Start Import At Line	2	
5	Format Type	Delimited	
6	Delimiter Type	Tab	
7	Delimiter Character	Tab	
8	Length Unit	mm	
9	Coordinate System Type	Cartesian	
10	Analytical Transformation		
11	X Coordinate	x	
12	Y Coordinate	y	
13	Rigid Transformation		
14	Origin X	0	mm
15	Origin Y	0	mm
16	Origin Z	0	mm
17	Theta XY	0	radian
18	Theta YZ	0	radian
19	Theta ZX	0	radian



Z Component ignored because imported data only available for X and Y

E.g. Choice of coordinate system

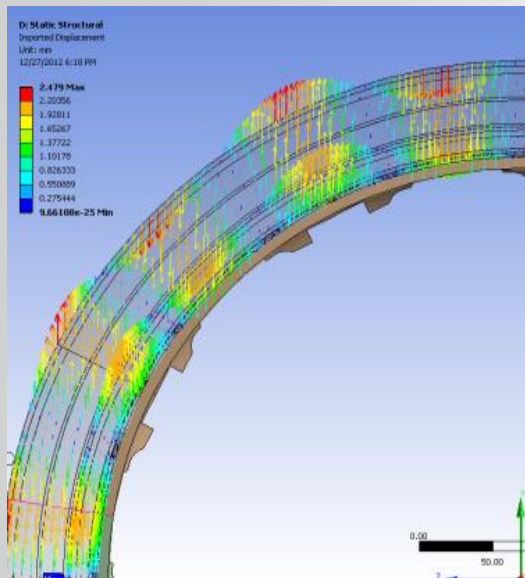


Default is "Source CS"

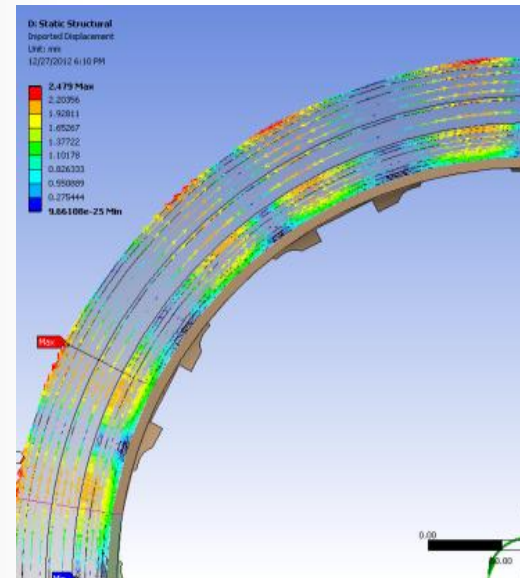
Any Local CS including Cylindrical

Properties of File - H:\Mapping_ppt\MODIFIED.csv

	A	B	C
1	Property	Value	Unit
2	Definition		
3	Dimension	3D	
4	Start Import At Line	1	
5	Format Type	Delimited	
6	Delimiter Type	Comma	
7	Delimiter Character	Comma	
8	Length Unit	mm	
9	Coordinate System Type	Cartesian	
10	Analytical Transformation		
11	X Coordinate	x	
12	Y Coordinate	y	
13	Z Coordinate	z	
14	Rigid Transformation		
15	Origin X	0	m
16	Origin Y	0	m



UY in Source CS



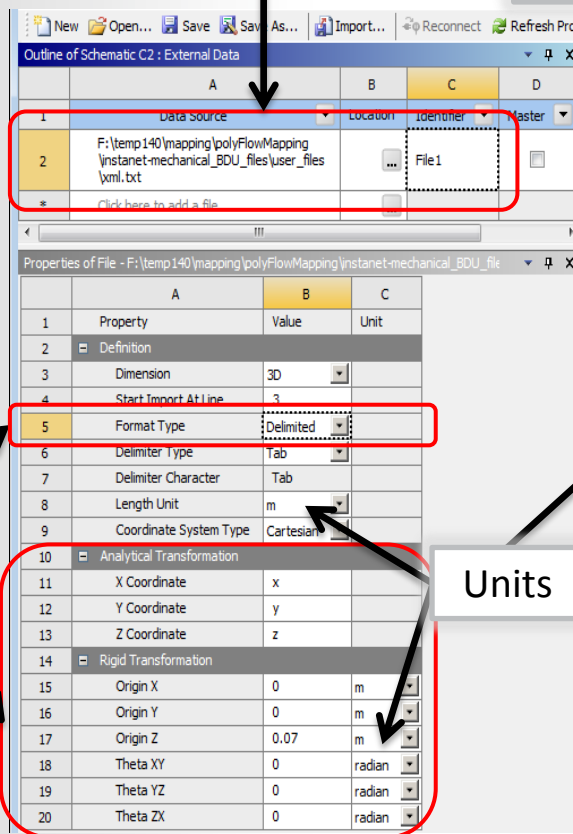
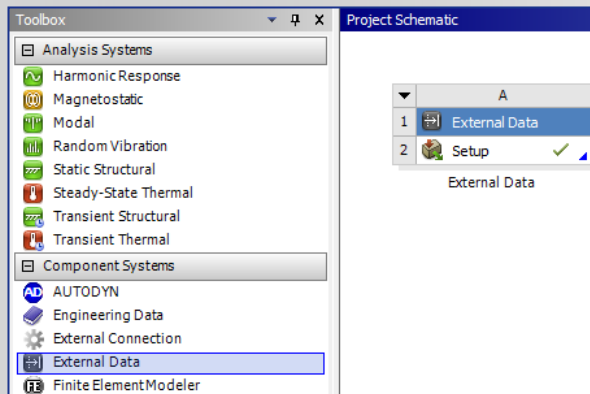
UY in Local Cylindrical CS

Summary Setup : External Data

1. Insertion of external data from GUI

2. File Name & path

5. Column Specification for data type, coordinate type etc.



Column	Data Type	Data Unit	Data Identifier	Combined
1	Not Used			File1
2	X Coordinate	m		File1
3	Y Coordinate	m		File1
4	Z Coordinate	m		File1
5	Thickness	m	Thickness1	File1:Thid

3. Format Specifier

4. Transforms for alignment of external data

6. Check Preview Pane

Units

	A	B	C	D	E
1	Not Used	X Coordinate	Y Coordinate	Z Coordinate	Thickness
2	91	0.3115486E-01	-0.2530528E-01	-0.5888583E-03	0.381636
3	7	0.3528232E-01	-0.2522993E-01	0.0000000E+00	0.488335
4	1	0.3530256E-01	-0.3300000E-01	0.0000000E+00	0.4885499
5	90	0.3116341E-01	-0.3300000E-01	-0.5787963E-03	0.382082
6	1170	0.3321859E-01	-0.2526760E-01	-0.2944292E-03	0.434985
7	1163	0.352924E-01	-0.2911496E-01	0.0000000E+00	0.488442
8	1164	0.3323299E-01	-0.3300000E-01	-0.2893981E-03	0.435316
9	1203	0.3115913E-01	-0.2915264E-01	-0.5838273E-03	0.381859
10	3461	0.3322579E-01	-0.2913380E-01	-0.2919136E-03	0.435150
11	100	0.3112998E-01	-0.1743390E-01	-0.6119511E-03	0.381463

Imported Data Inside Mechanical

Imported Load Folder created

Option such as scoping and mapping controls

If source data is 2D, Projection option is available

Mapped Data is displayed

Support for scale, offset, multiple load steps via worksheet

Outline

- Project
 - Model (B4)
 - Geometry
 - FirTree
 - Slot
 - Solid
 - Coordinate Systems
 - Connections
 - Mesh
 - Static Structural (B5)
 - Analysis Settings
 - Imported Load (Setup 2)
 - Imported Body Temperature
 - Imported Load Transfer Summary
 - Fixed Support
 - Fixed Support 2
 - Pressure
 - Solution (B6)
 - Solution Information
 - USER BFE

Details of "Imported Body Temperature"

- Scope**
 - Scoping Method: Geometry Selection
 - Geometry: 1 Body
- Definition**
 - Type: Imported Body Temperature
 - Suppressed: No
- Beta Options (Beta)**
 - Show Body Wireframe (Beta): No
- Settings**
 - Mapping Control: Program Controlled
 - Mapping: Profile Preserving
 - 2D Projection: Coordinate System 4
- Graphics Controls**
 - Display Source Points: True
 - Display Projection Plane: True
 - Display Interior Points: False

B: Static Structural (3D)
 Imported Body Temperature
 Unit: °C
 7/20/2010 1:20 PM

398.38 Max
 391.8
 385.21
 378.63
 372.04
 365.46
 358.87
 352.29
 345.7
 339.12 Min

Imported Body Temperature

	Magnitude (°C)	Analysis Time (s)	Scale	Offset (Δ°C)
1	File1:Temperature1	1	1	0
*				

Scoping entities

- **Node to Node Load import:** import data on nodes (displacement, force, and temperature) can be scoped to **node-based Named Selections**
- **Temperature and Displacement loads** can be scoped also to all geometry entity types (body, face, edge, or vertex).



The screenshot displays the ANSYS Workbench environment. The **Outline** tree on the left shows the hierarchy: Project > Model (D4) > Static Structural (D5) > Imported Body Temperature. A red box highlights the 'Imported Body Temperature' feature, and a red arrow points from it to the 'Details of "Imported Body Temperature"' panel.

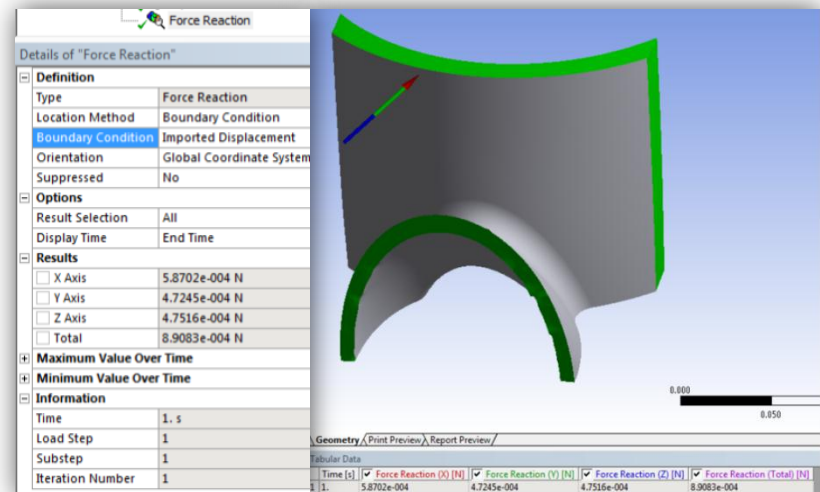
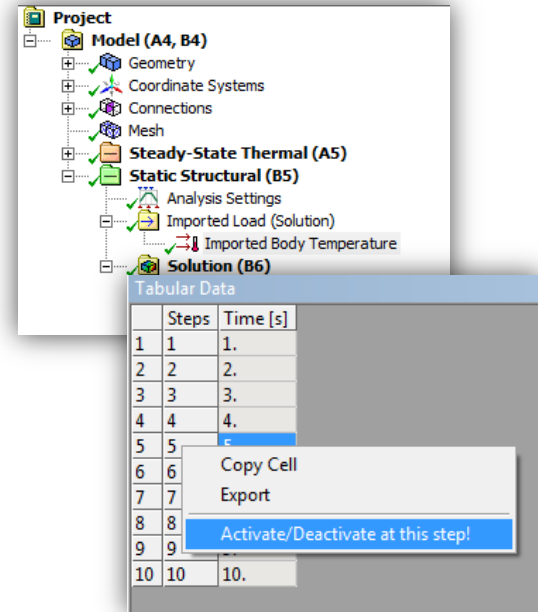
The **Details of "Imported Body Temperature"** panel shows the following settings:

Details of "Imported Body Temperature"	
Scope	
Scoping Method	Named Selection
Named Selection	Selection 2
Definition	
Type	Imported Body Temperature
Suppressed	No
Source Bodies	All
Submodeling Type	3D to 3D
Transfer Key	Solid-Solid
Settings	
Mapping Control	Manual
Mapping	Profile Preserving
Weighting	Triangulation
Transfer Type	Volumetric
Rigid Transformation	
Graphics Controls	
Named Selection Creation	
Advanced	

On the right, a 3D model of a rectangular block is shown with a mesh. A red square on the block's surface indicates the location of the 'Imported Body Temperature' load. The top right corner of the window displays the title 'D: Static Structural' and the date/time '4/23/2012 9:25 AM'.

Load Step and Reaction Results

- User can control activation/
deactivation of Imported Loads per
load step. E.g. Turn “off” an imported
load in a subsequent load step.
 - Available for all imported loads
- Reaction Probes have been
augmented to allow scoping to
Imported Displacement and Imported
Temperature loads



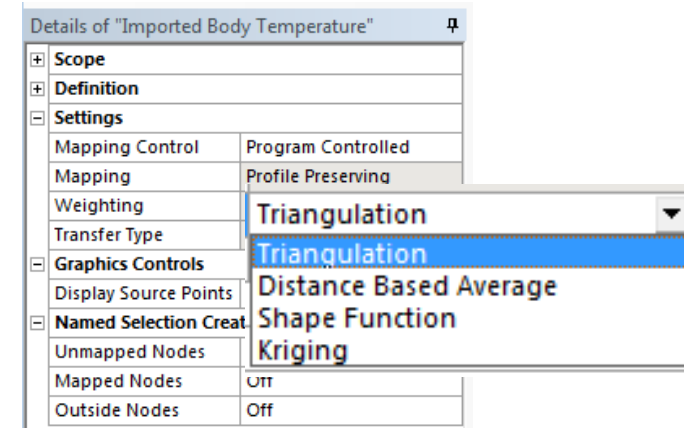
What's under the hood:

Weighting Options

How to identify and use a source – target data map?

By using Weighting Algorithms

- **Triangulation:** *Works well in most cases. *MOPER equivalent. Works best if target points are found within the source point cloud*
- **Distance Based Average:** *Simple robust method which can give a mapping when other methods fail*
- **Kriging:** *Regression-based interpolation technique that can give smoother mapping*
- **Shape Function:** *Available when source element data are available (via .cdb input)*
- **UV Mapping (R15)** – *Map data from source to target in UV space*



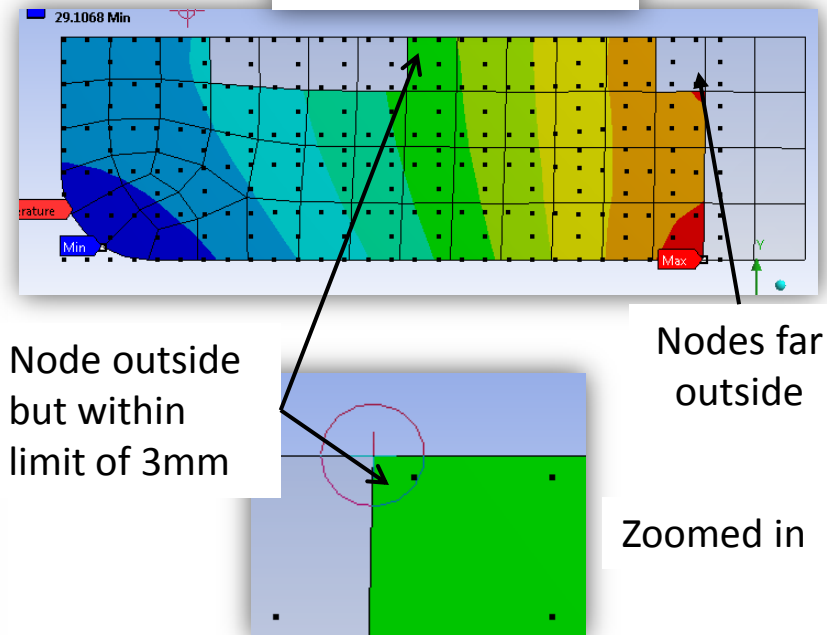
- **Key Idea:** to find source-target points correlation by using Tet cells from source points

- **Available Options:**

If source data set is wider than target, you may find useful to filter data by:

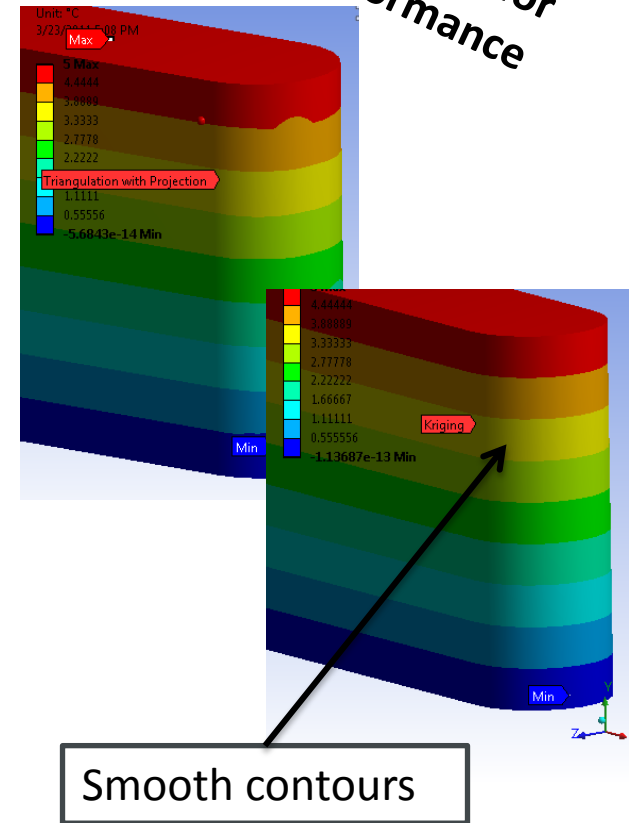
- **Pinball region** filter for closest source point;
- **Limit** the number of nearby points considered for interpolation;
- **Ignore** outside points
- Thickness offsets (target surface)

Mapping	Profile Preservi..
Weighting	Triangulation
[-] Graphics Controls	
Display Source Points	On
Display Interior Points	Off
[-] Named Selection Creation	
Unmapped Nodes	On
-- Name	Unmapped No..
Mapped Nodes	On
-- Name	Mapped Nodes
Outside Nodes	On
-- Name	Outside Nodes
[-] Advanced	
Pinball	Program Contr..
Limit	20
Outside Option	Distance Base...
Number of Points	3
Outside Distance Chec...	On
-- Maximum Distance	3. mm



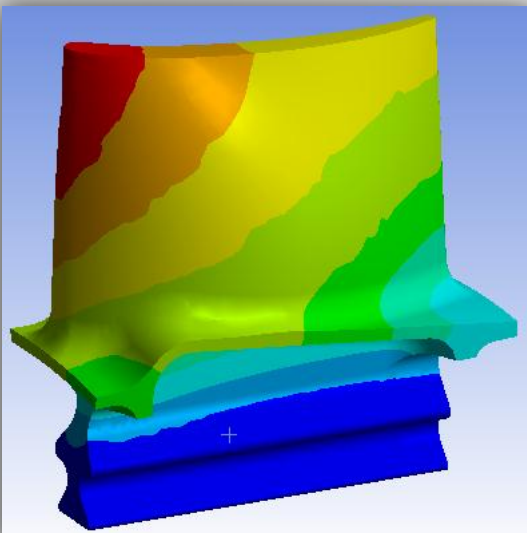
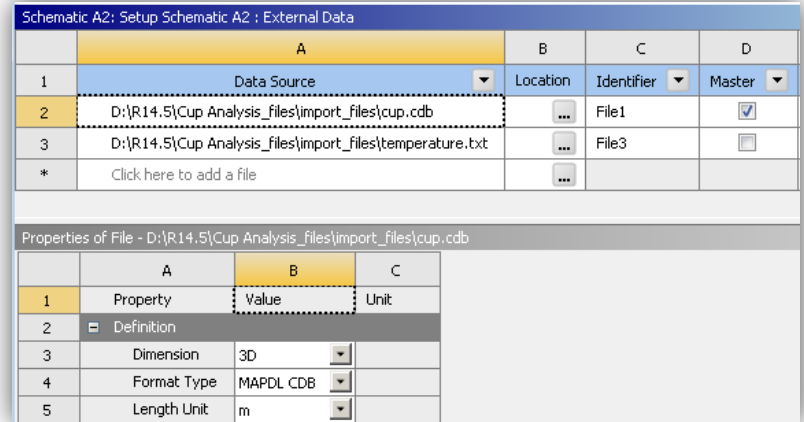
- **Key Idea:** use a Regression-based interpolation technique to assign weights to surrounding source points according to their spatial covariance values
- **Available options:**
 - **Pinball** option to control finding closest source point
 - **Correlation Function:** model the spatial correlation between the sample points
 - **Extrapolation Tolerance:** ensure that interpolated value for each target point lies within specific limits
 - **Polynomial:** change the mathematical function that is used to globally approximate the sample

Completely Parallelized for
fast mapping performance

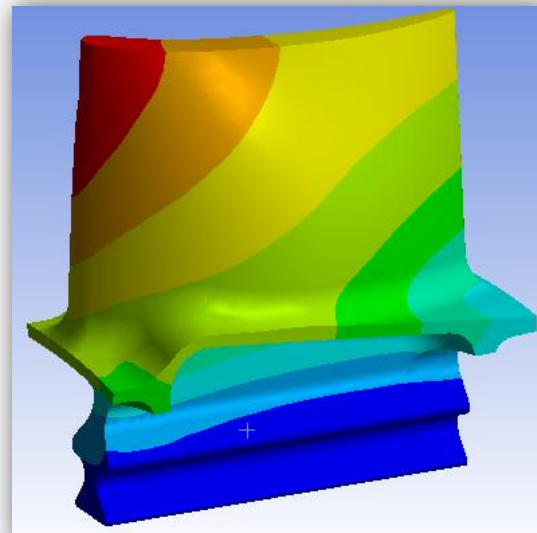


Shape Function – .CDB element data

- External Data System now allows MAPDL CDB format to be selected allowing for nodal and element connectivity information to be provided to the mapping tool.

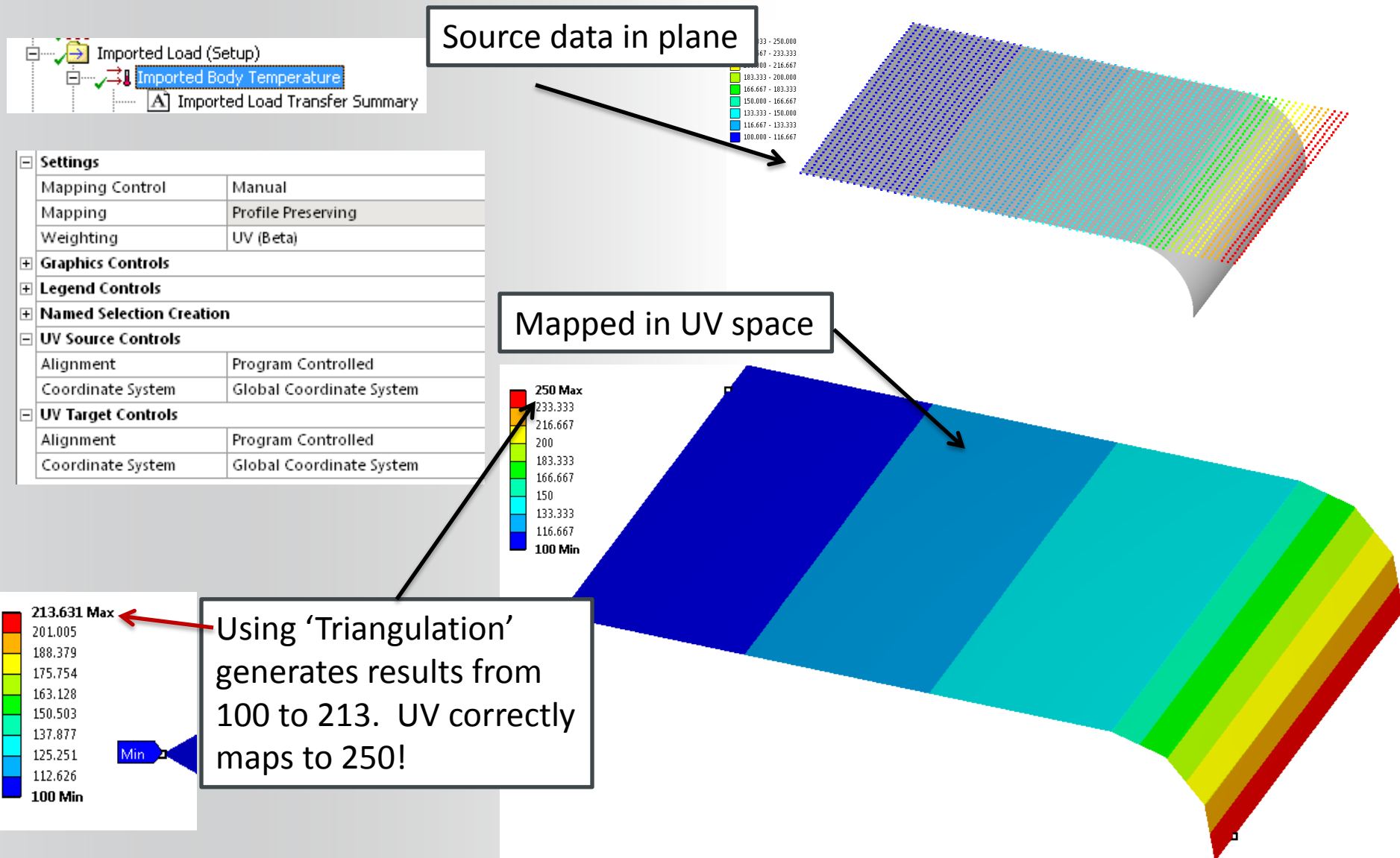


Temperature mapping using triangulation (Nodes Only)



Temperature mapping using shape functions

New 'UV' option for imported loads (R15)



Scaling: Conserve Applied load

- The mapping algorithms used inside Mechanical are profile preserving, not conservative.
- For Imported Force loads, additional results are reported in the Transfer Summary to appropriately scale the mapped data.

The screenshot displays the ANSYS Mechanical interface. The 'Outline' pane on the left shows the project hierarchy, with 'Imported Load Transfer Summary' selected under the 'Imported Force' load. The 'Details of "Imported Load Transfer Summary"' pane shows the 'Author' field. The 'Data View' window at the bottom left shows the 'Imported Force' table. The 'Comment' pane on the right provides detailed information about the load transfer process, including node counts and mapping statistics.

Imported Load Transfer Summary (Table 1)

Row	Force X (N)	Force Y (N)	Force Z (N)	Total Force (N)	Force X (N)	Force Y (N)	Force Z (N)	Total Force (N)	Scale Factor (N)
1	11.177	0	-7.6382	13.538	32.66	0	-22.423	39.617	0.34172

Data View (Table 2)

X Component (N)	Y Component (N)	Z Component (N)	Analysis Time (s)	Scale
File1:ForceX	Ignore	File3:ForceZ	1	1

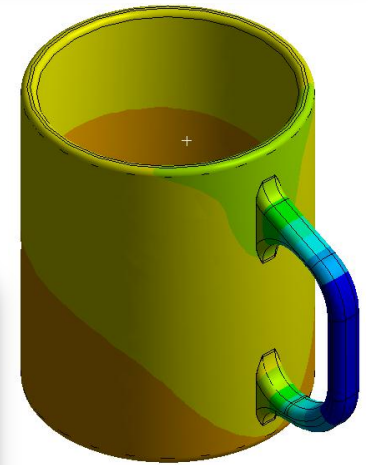
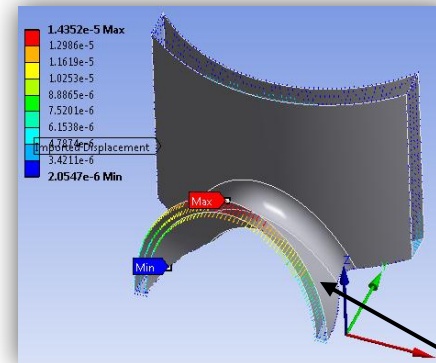
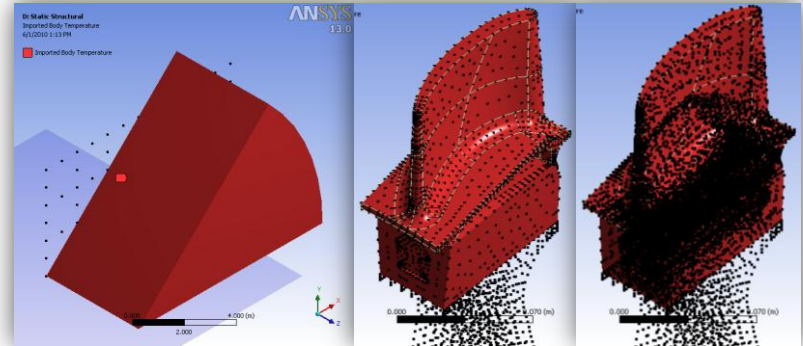
Comment (Table 3)

Source	Target
Force X (N)	Force X (N)
Force Y (N)	Force Y (N)
Force Z (N)	Force Z (N)
Total Force (N)	Total Force (N)

Note: Results are reported in the Global Coordinate System and do not include any Scale or Offset values specified in the worksheet.

Validation & Diagnostics

- **Graphics Control**
 - Visualize source points on target geometry
 - Display the projection plane
 - Hide/Show source points falling inside the target model
 - View Mapped data as Contours, isolines
 - For Vector Data, option to plot components, magnitude or vectors

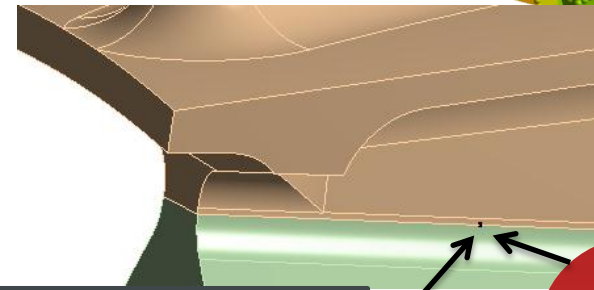
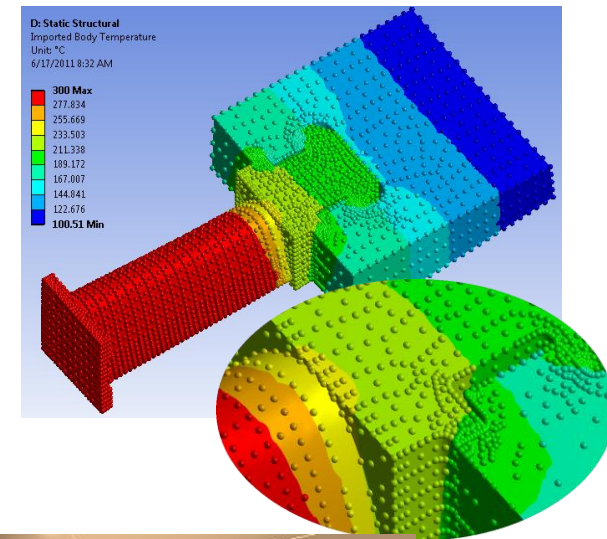
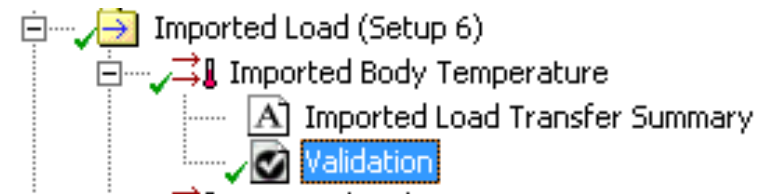


All vectors plot

Validation Object

A **Validation Object** can be used to determine **how well the data has been mapped** onto the target

- **Reverse Mapping** Difference between source and mapped data
- **Distance Based Average Comparison:** Compare mapped data to distance based average mapping results
- **Source Values:** Plots the source data which can allow for visual comparison against mapped data
- **Undefined Points (R145)** shows which nodes did not get mapped data



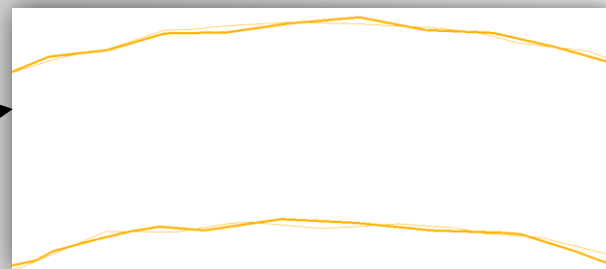
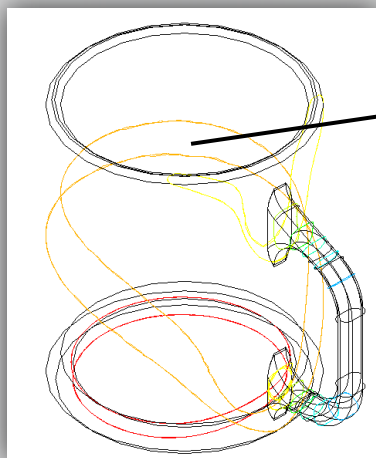
Overlay with node ids turned shows problematic node.
The file does not contain data for 10146

12388

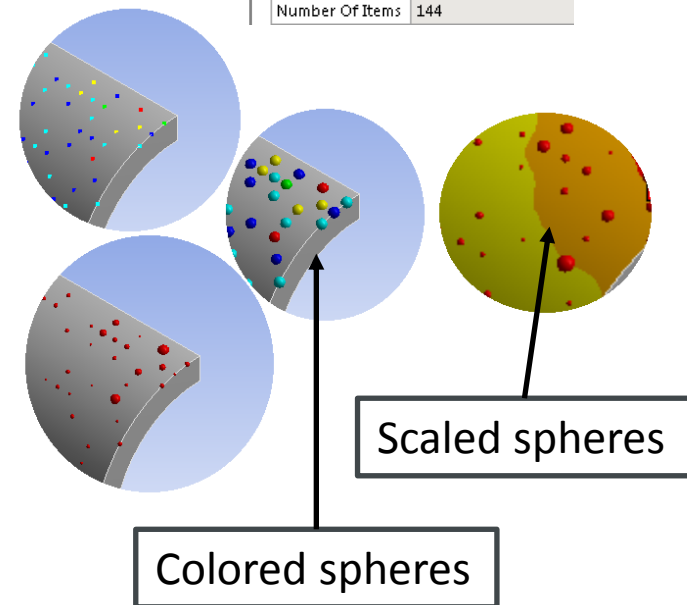
10146

Validation Graphic Controls

- **Colored Points (default) or Colored Spheres**
- **Scaled Spheres** are spheres drawn based on Display Min and Max
- **Isolines to show contour boundaries**
- **Display In Parent** to *compare source and target data*



Overlay with source
using double thickness



Details of "Validation"	
Definition	
File Identifier	File1:Temperature1
Settings	
Type	Reverse Mapping
Output Type	Absolute Difference
Graphics Controls	
Display	Scaled Spheres
Scale	1.
Display Minimum	4.e-002 C
Display Maximum	0.20894 C
Display In Parent	On
Statistics	
Minimum	2.91567e-005 C
Maximum	0.20894 C
Number Of Items	144

Diagnostic Information

- After mapping is completed, diagnostic information is output to give additional details about the mapping

The screenshot displays the ANSYS Static Structural - Mechanical [ANSYS Multiphysics] interface. The Outline panel on the left shows the project hierarchy, with the 'Imported Load Transfer Summary' selected under the 'Solution (B6)' branch. The main window shows the 'Comment' tab, which contains diagnostic information about the mapping process.

Diagnostic Information:

- Mon Mar 12, 2012 14:17:55
- Using multiple cores: [Yes]
- Number of cores requested: 12
- Maximum source mesh bounding box length: 0.07604 (m)
- Maximum range used in sorting closest nodes: 0.07604 (m)
- Number of source nodes: 56
- Number of target nodes: 164
- Number of nodes mapped : 164
- Number of nodes not mapped : 0
- Number of nodes outside : 0
- Percent nodes mapped: 100%
- Weight calculation time: 9.1e-002 (s)
- Interpolation time: 1.e-003 (s)

Results:

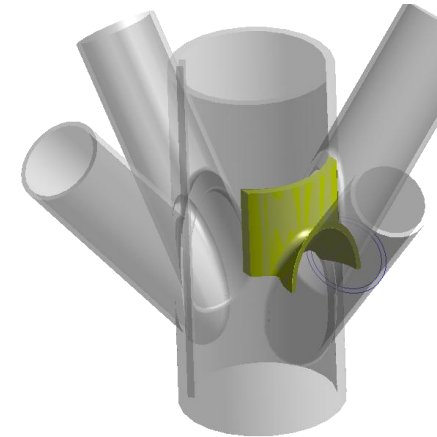
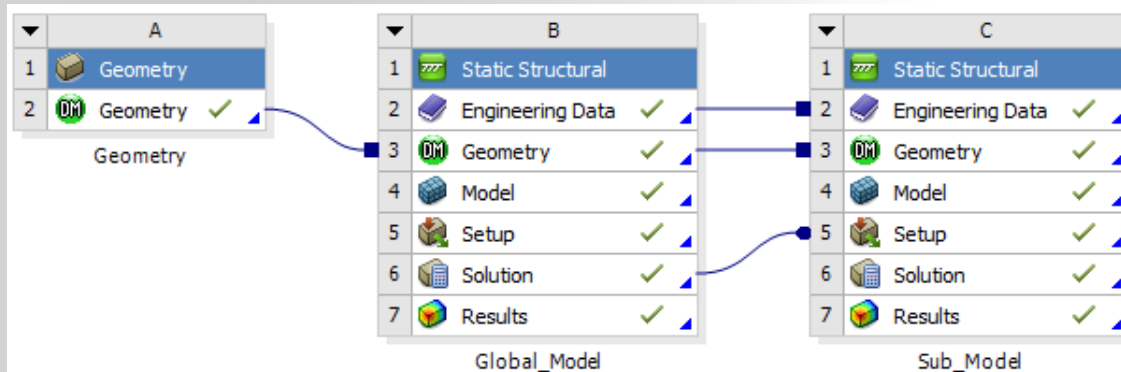
Row	Source				Target				Scale Factor (N)
	Force X (N)	Force Y (N)	Force Z (N)	Total Force (N)	Force X (N)	Force Y (N)	Force Z (N)	Total Force (N)	
1	11.177	0.	-7.6382	13.538	32.66	0.	-22.423	39.617	0.34172

Note: Results are reported in the Global Coordinate System and do not include any Scale or Offset values specified in the worksheet.

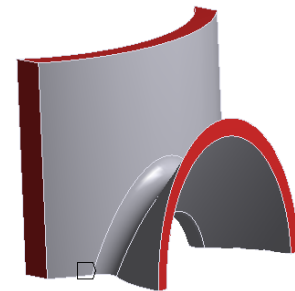
Some more sophisticated examples of data mapping

Introduction to Submodeling

- Submodeling is a finite element technique that you can use to obtain more accurate results in a particular region of a model
- Submodeling is based on de St. Venant's principle.

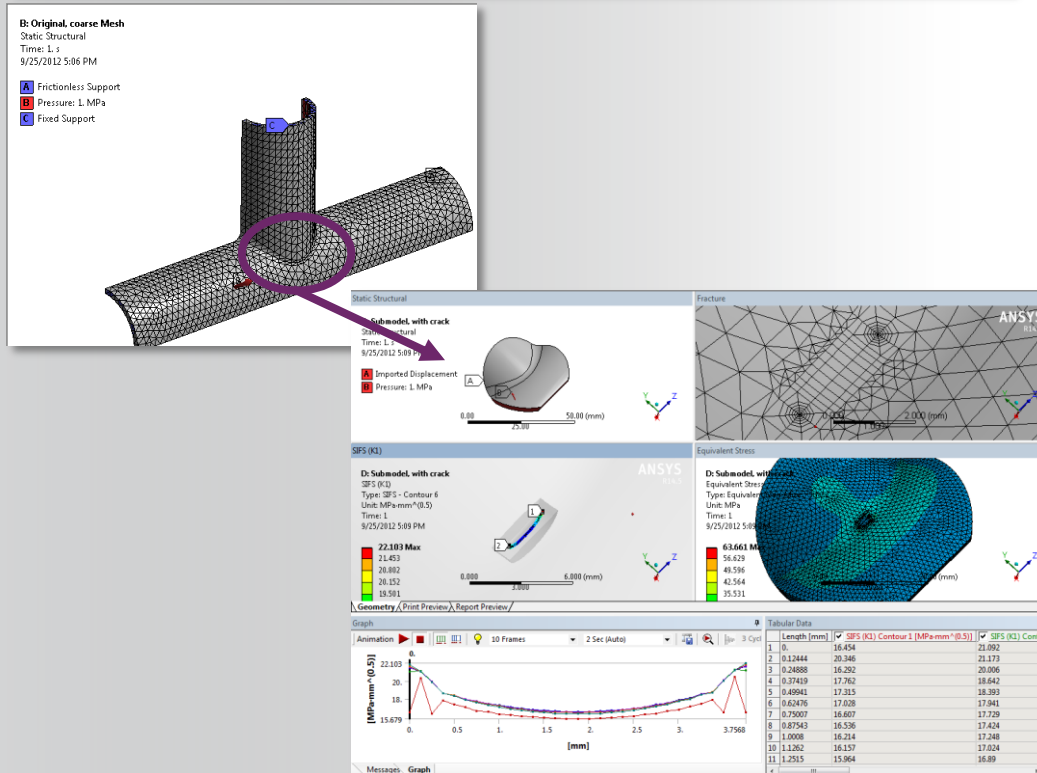
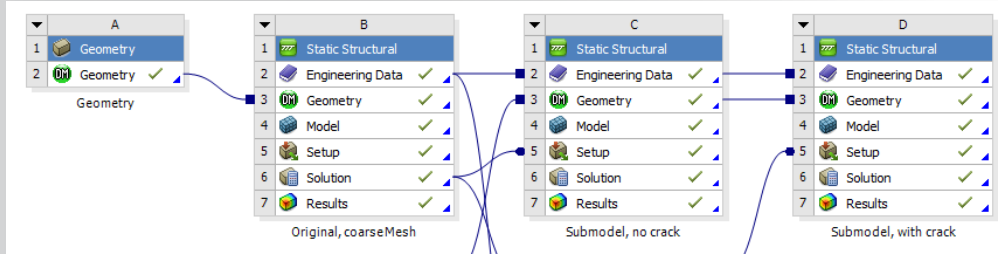


Global Model



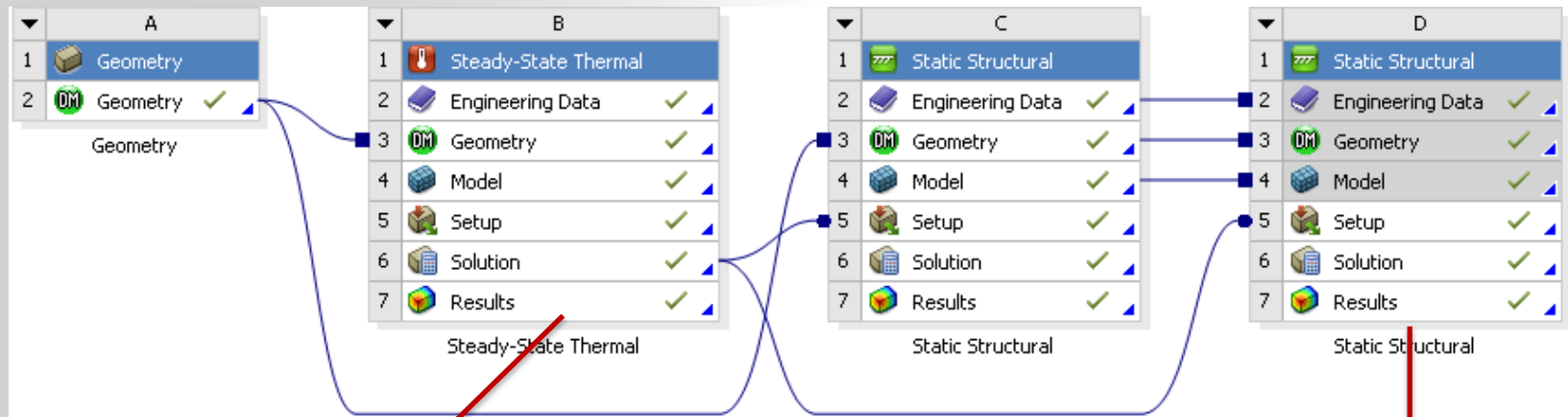
Sub Model

Example Application – Fracture

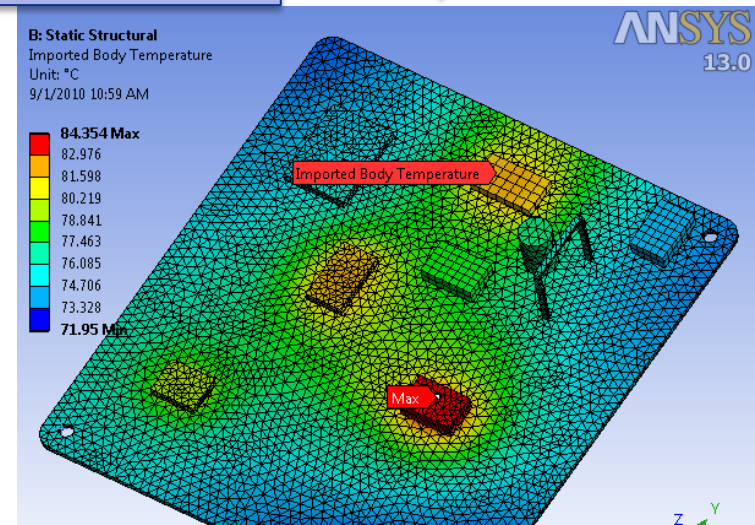
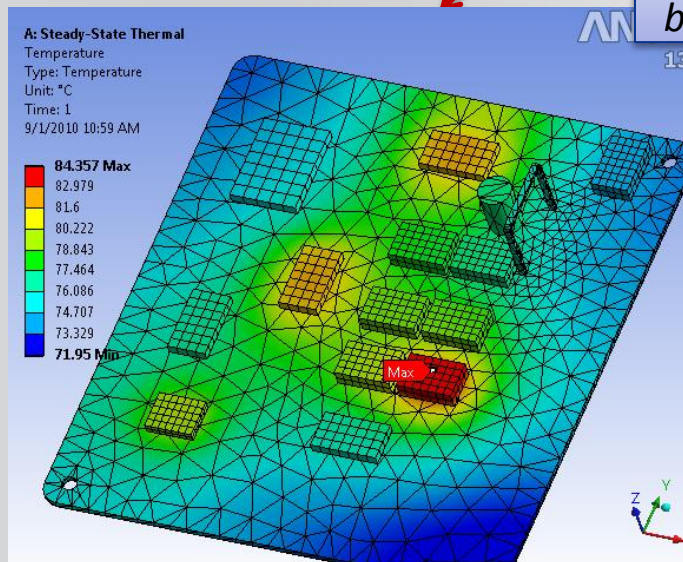


A crack can be introduced in a submodel to reduce overall computation time while increasing the local accuracy.

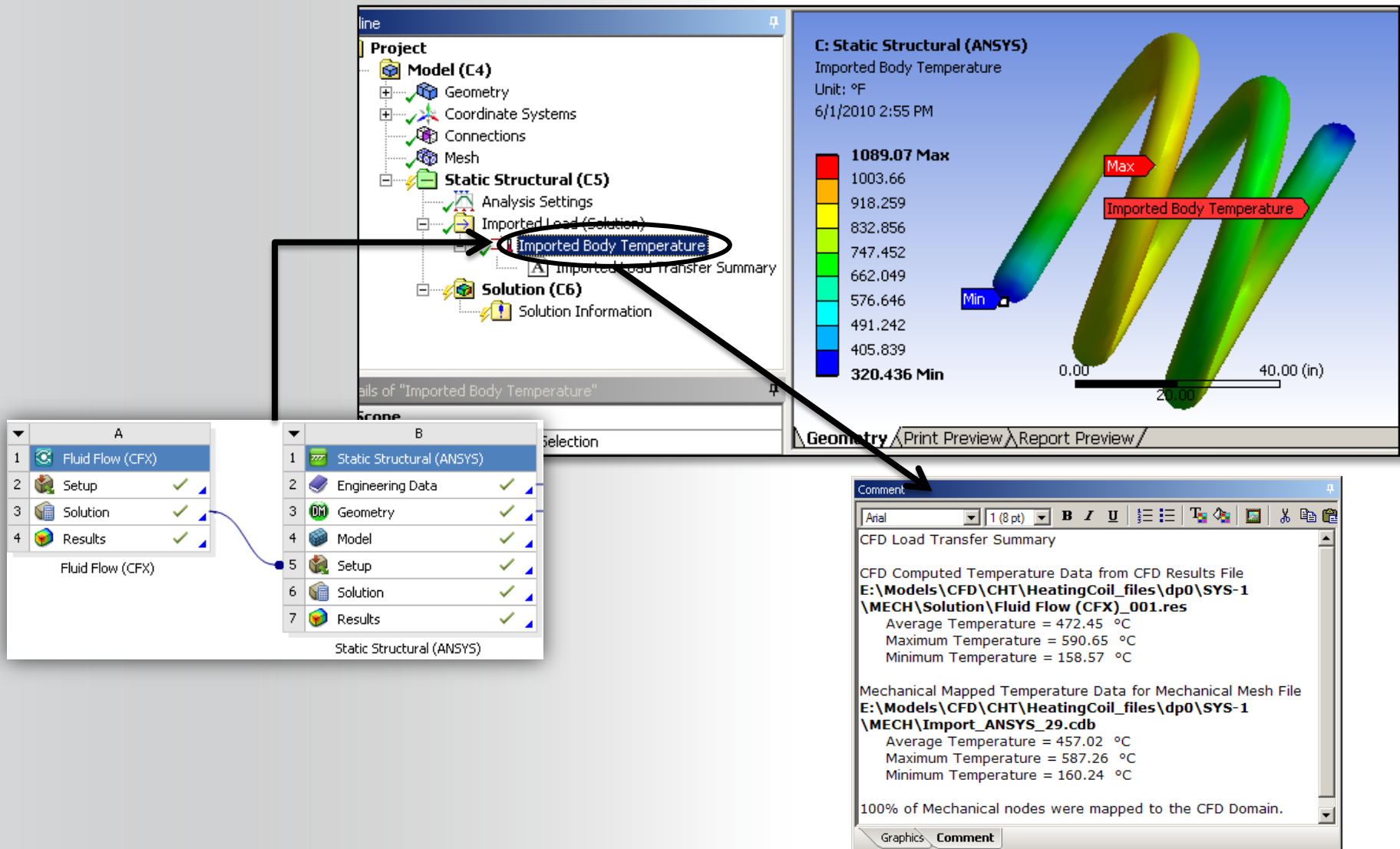
E.g. Thermal-Stress Analysis



Automatically Handle 'scoping' to prevent **bleed across body boundaries**.

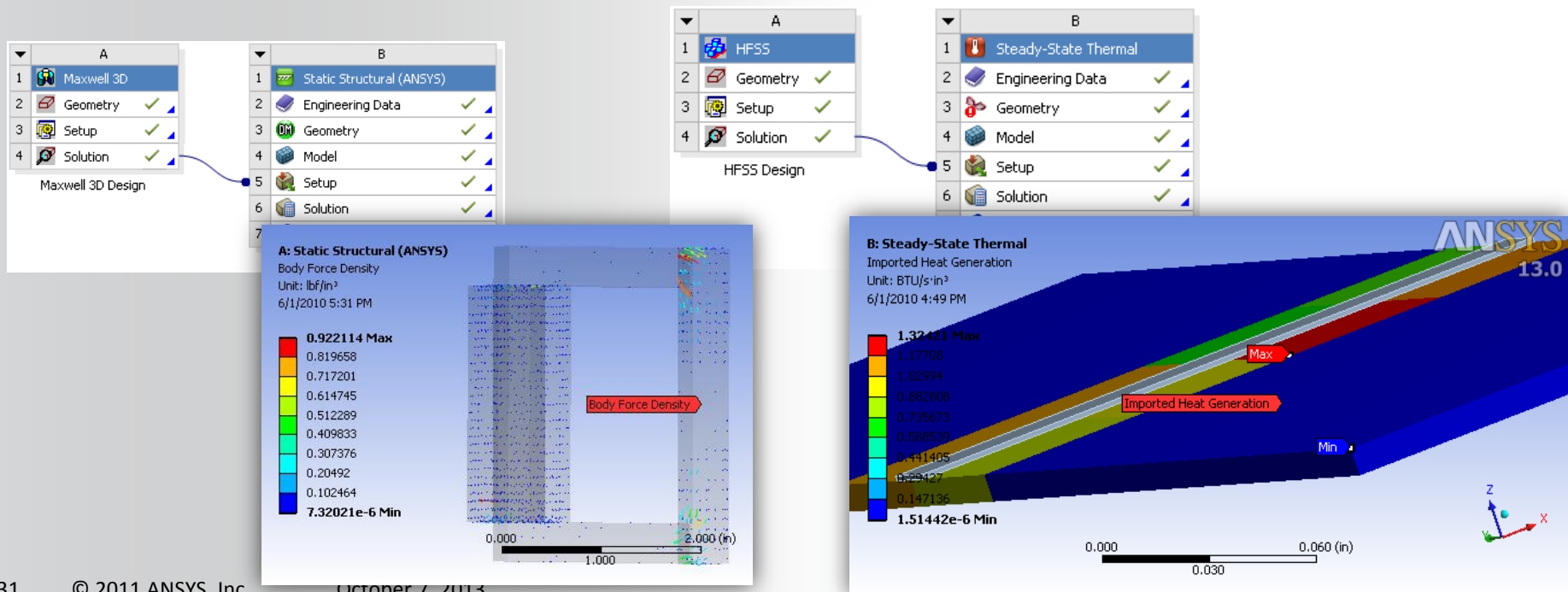


CFD to Mechanical Volumetric Temperature Transfer



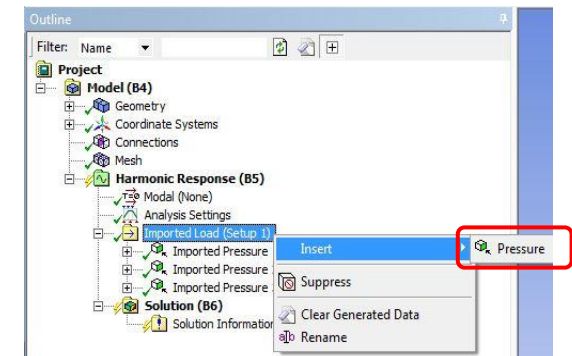
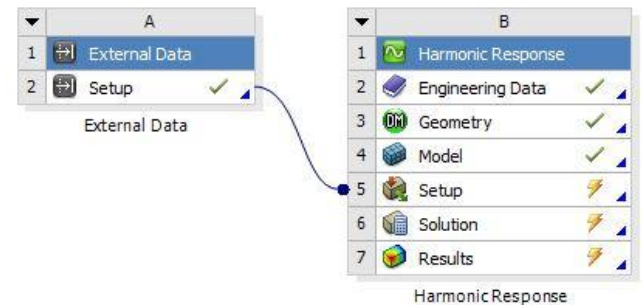
E.g. Mechanical – Maxwell/HFSS

- **From Maxwell/HFSS:** Import Heat Generation/Heat Flux to Mechanical
- **From Mechanical:** Export Thermal Results to Maxwell/HFSS
- **From Maxwell:** Import Surface/Body Force Densities to Mechanical



Support for Imported Pressures in a Harmonic Analysis

- Users can import pressure data and apply in a downstream harmonic analysis
- Ability to prescribe real and imaginary components (normal to and defined by components)
- Ability to display real and imaginary components in the graphics display



Definition	
Type	Imported Pressure
Suppressed	No
Define By	Normal To

Graphics Controls	
Complex Data Component	Real
Data	Imaginary
Display Source Points	Real

Definition	
Type	Imported Pressure
Suppressed	No
Define By	Components
Coordinate System	Coordinate System 3

Imported Pressure

	Magnitude [Real] (Pa)	Magnitude [Imag] (Pa)	Scale [Real]	Offset [Real] (Pa)	Scale [Imag]	Offset [Imag] (Pa)
1	File1:Pressure Real Normal	File1:Pressure Imaginary Normal	1	0	1	0

Imported Pressure 3

	Radial Component [Real] (Pa)	Radial Component [Imag] (Pa)	Tangential Component [Real] (Pa)	Tangential Component [Imag] (Pa)	Axial Component [Real] (Pa)	Axial Component [Imag] (Pa)	Scale [Real]	Offset [Real] (Pa)	Scale [Imag]	Offset [Imag] (Pa)
1	File1:Pressure Radial	Ignore	Ignore	File1:Pressure Tangential	Ignore	File1:Pressure Axial	1	0	1	0

Conclusions

- ✓ External Data and Imported Load allow for fast and accurate mapping of cloud data into your Structural/Thermal analyses
- ✓ Many simulation techniques take advantage from ANSYS Data Mapping technology, boosting your simulation activity

