ANSYS

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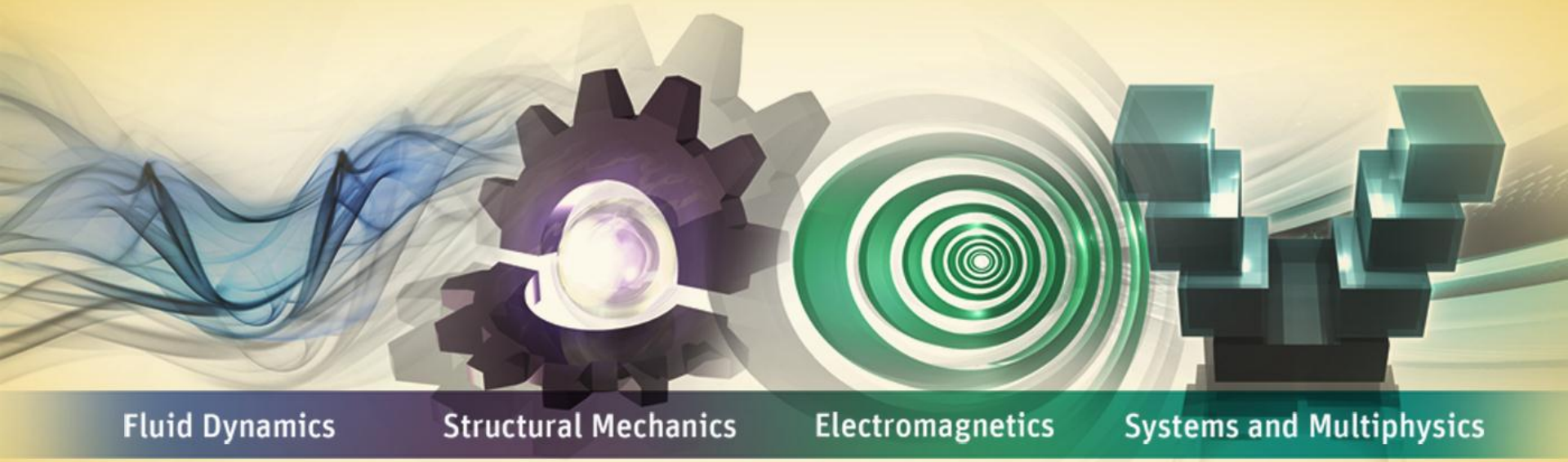
Mapping External Data on Structural Mesh



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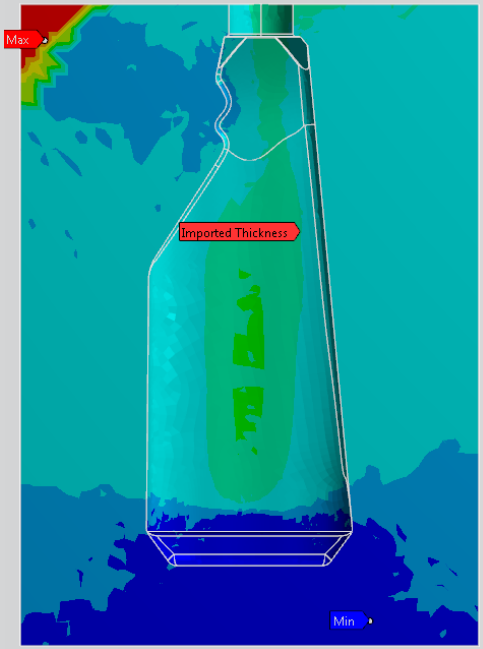
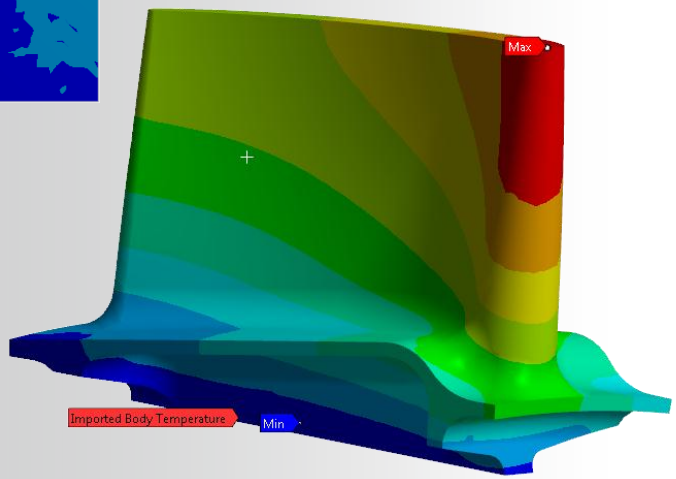
Application Engineer

ANSYS Italia

Motivation





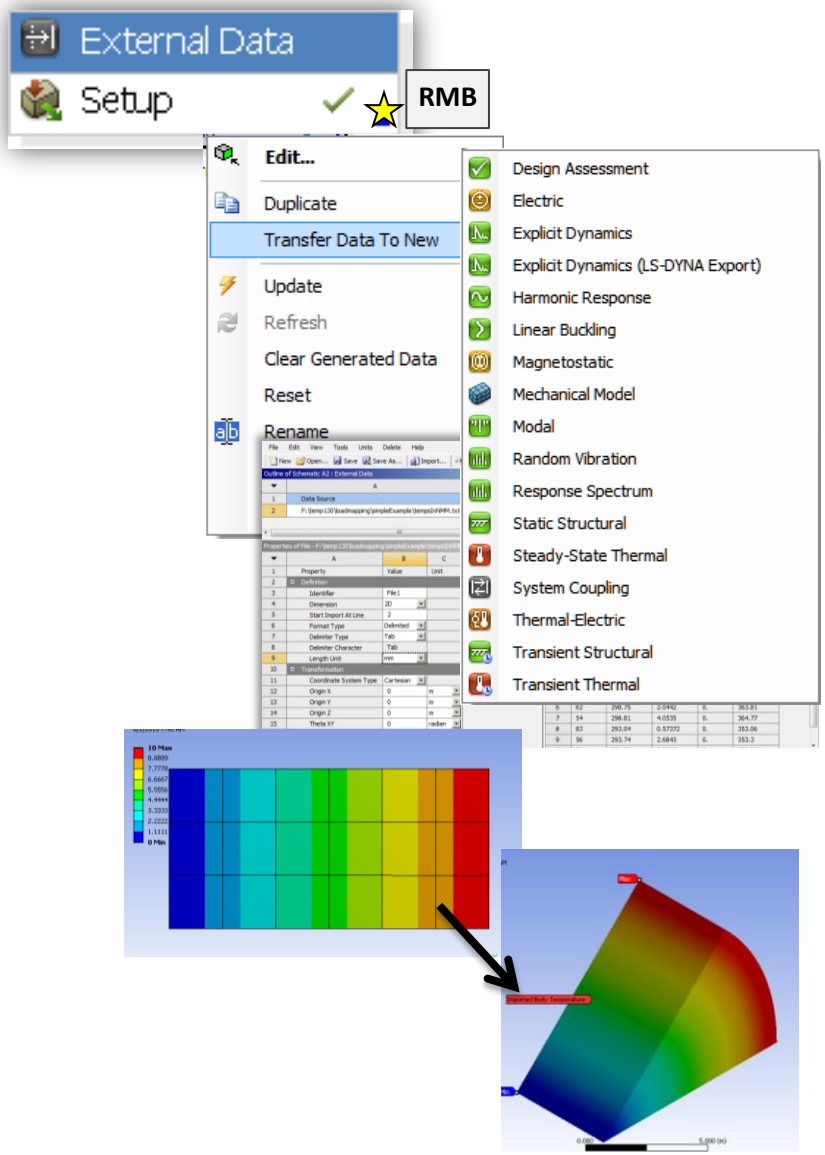
Exchange files are frequently used to transfer quantities from one simulation to another.

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

External Data - Features

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

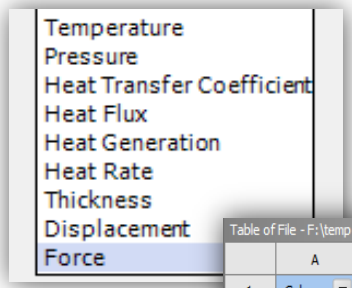
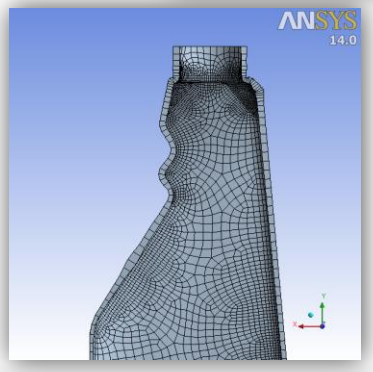
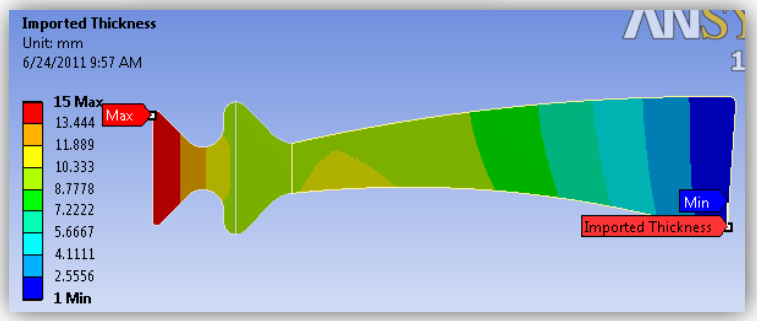


Table of File - F:\temp140\mapping\polyFlowMapping\instanet-mechanical_BDU_

	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)

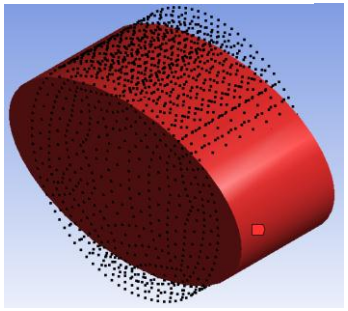
Outline of Schematic A2 : External Data

	A	B	C	D	E
1	Data Source	Location	Identifier	Master	Description
2	C:\Users\azaffora\Desktop\hs_err_pid6684.log	...	File1		
3	C:\Users\azaffora\Downloads\case_with_fix_support.txt	...	File2		
4	C:\Users\azaffora\Downloads\ANSYS1-4VNOR7.txt	...	File3		
5	C:\Users\azaffora\Downloads\case_with_snippet.txt	...	File4		
*	Click here to add a file	...			

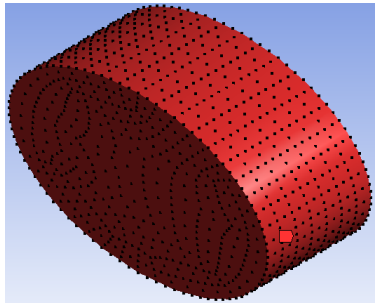
Rigid Transforms

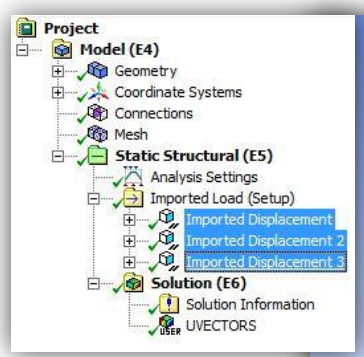
- Source Point**, Analytical Transformation of data**
- Transforms can also be applied to **Imported vector data**
- **Use Coordinate System property** to apply data in a user-defined coordinate system.

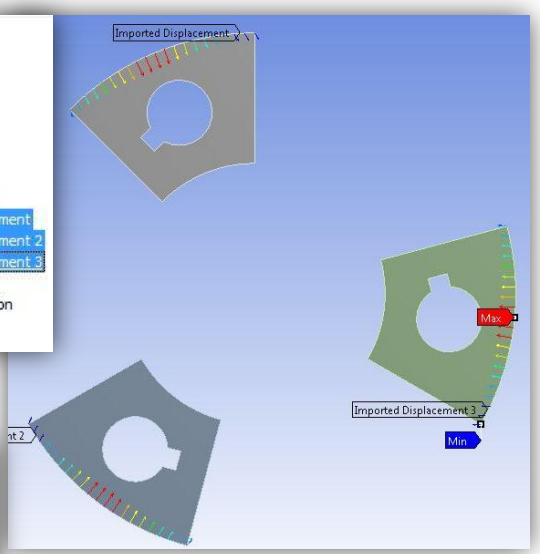
Original source



Transformed source







Data Source	Location	Identifier
\\cantbsrv\TestBench\testsetlib\Products\MBU\Scripts\EXT_DISP_TO_MECH_001.txt	...	File1
\\cantbsrv\TestBench\testsetlib\Products\MBU\Scripts\EXT_DISP_TO_MECH_001.txt	...	File2
\\cantbsrv\TestBench\testsetlib\Products\MBU\Scripts\EXT_DISP_TO_MECH_001.txt	...	File3
Click here to add a file	...	

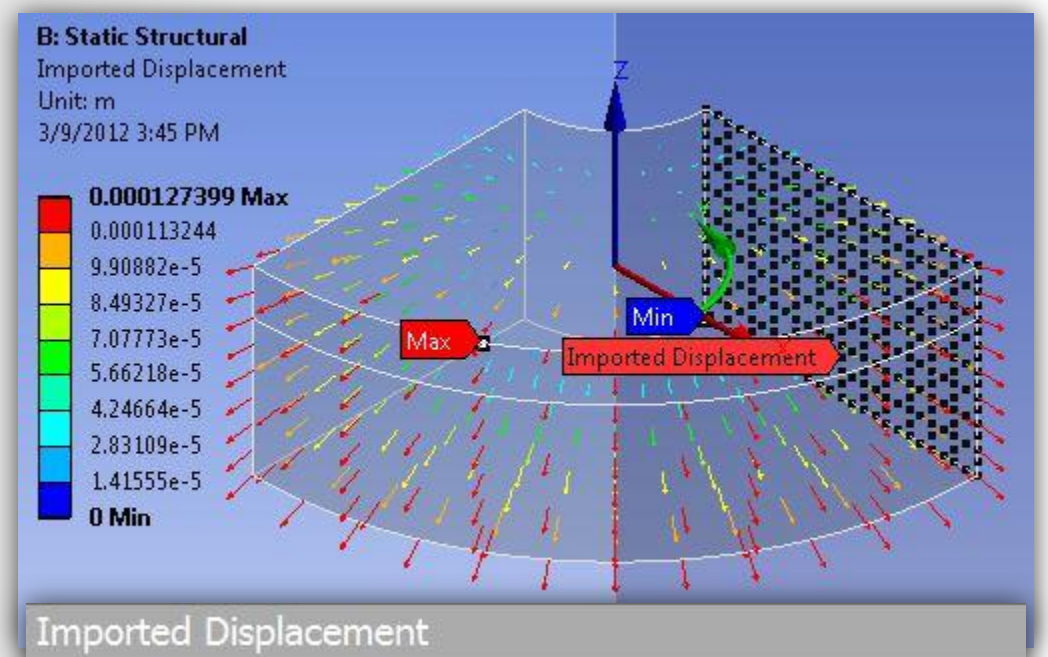
Rigid Transformation		
Origin X	0	m
Origin Y	0	m
Origin Z	0	m
Theta XY	120	degree
Theta YZ	0	degree
Theta ZX	0	degree

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



Imported Displacement

	X Component (m)	Y Component (m)	Z Component (m)	Analysis Time (s)	Scale
1	File1:DisplacementX	File2:DisplacementY	Ignore	1	1
*					

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

E.g. Choice of coordinate system

Details of "Imported Displacement"

Scope	
Scoping Method	Named Selection
Named Selection	map_face
Definition	
Type	Imported Displacement
Suppressed	No
Override Constraints	No
Define By	Components
Coordinate System	Source Coordinate System
Graphics Controls	
Data	
Display Source Points	Off
Display Source Point Ids	Off
Beta Options (Beta)	
Show Body Wireframe (Beta)	No
Settings	

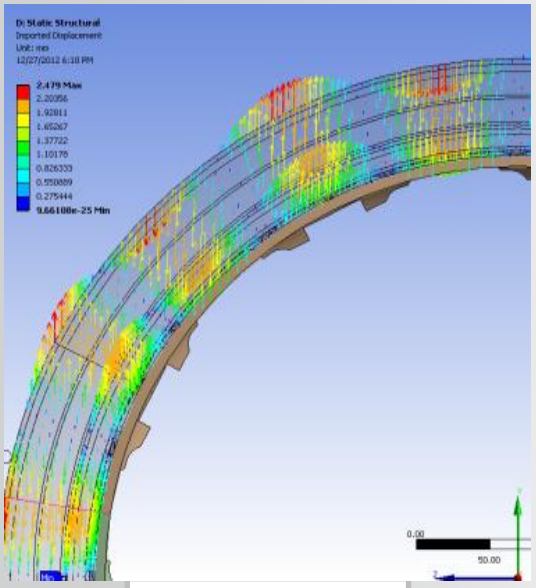
Source Coordinate System
Global Coordinate System
Coordinate System

Default is "Source CS"

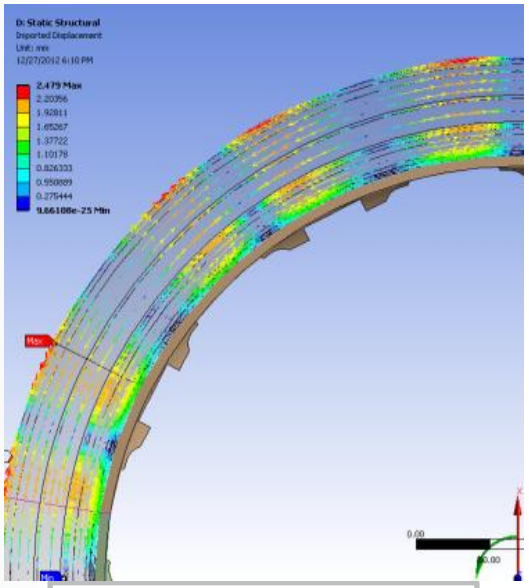
Any Local CS including Cylindrical

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



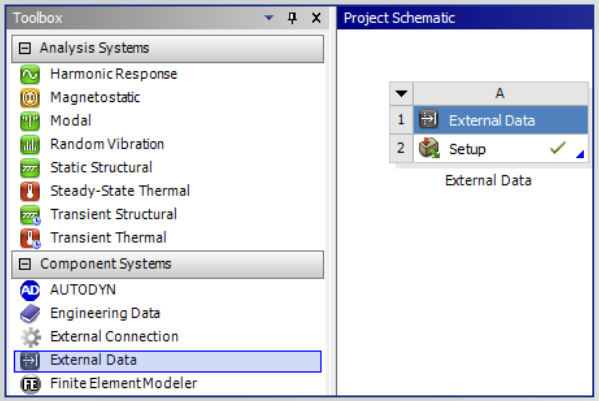
UY in Local Cylindrical CS

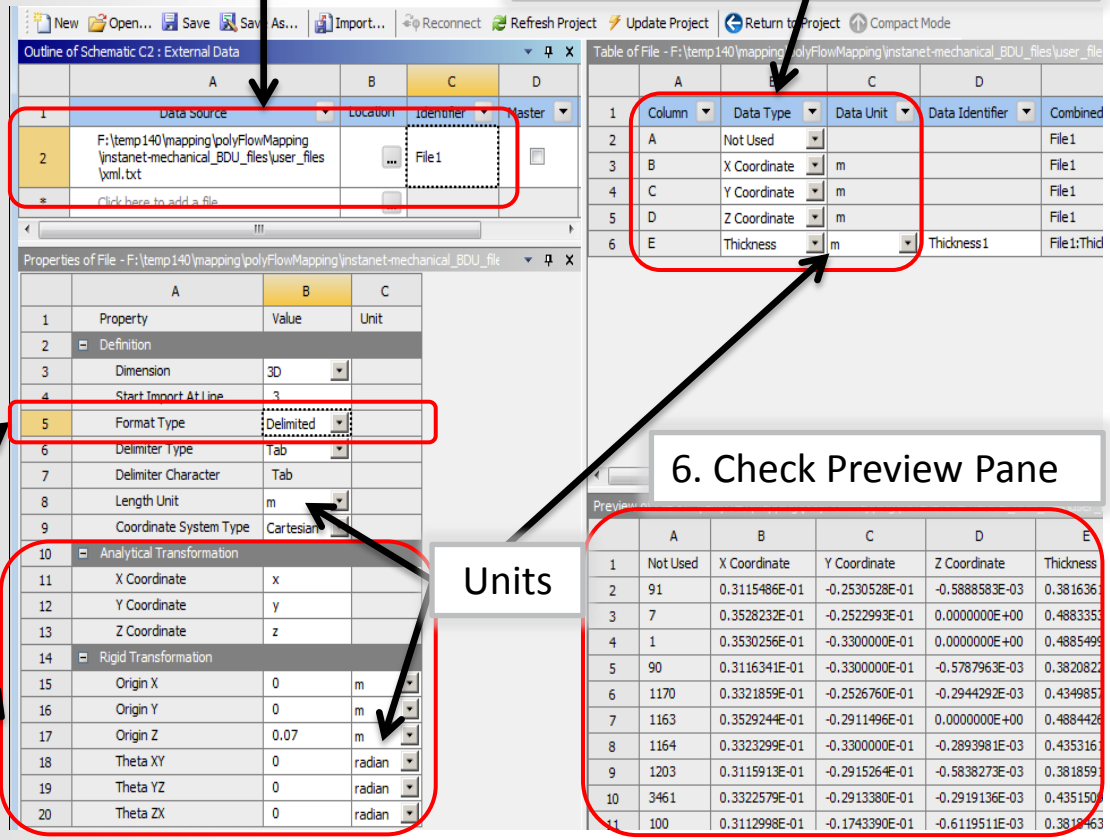
Summary Setup : External Data

1. Insertion of external data from GUI

2. File Name & path

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





3. Format Specifier

4. Transforms for alignment of external data

Units

6. Check Preview Pane

Imported Data Inside Mechanical

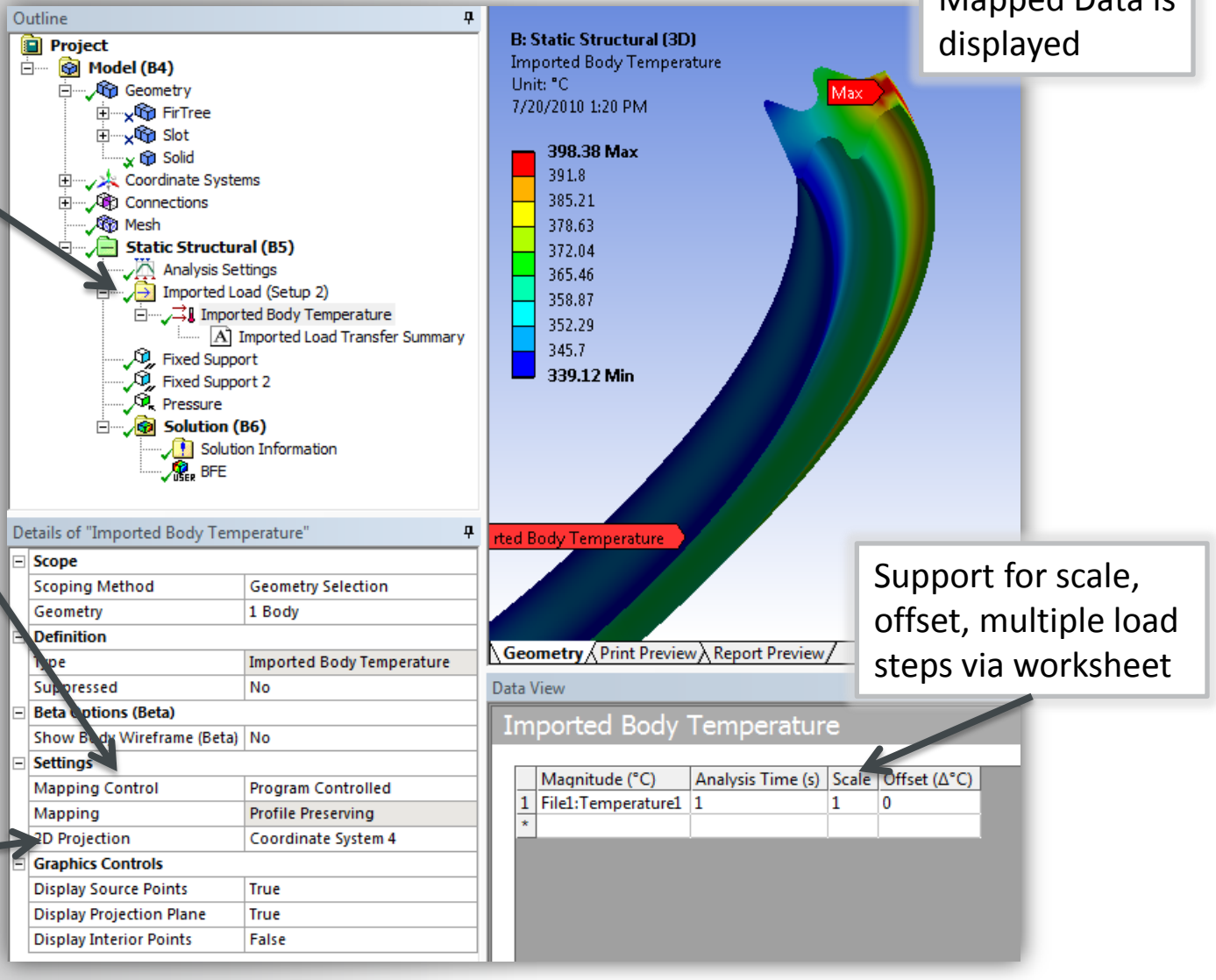
Imported Load Folder created

Option such as scoping and mapping controls

If source data is 2D, Projection option is available

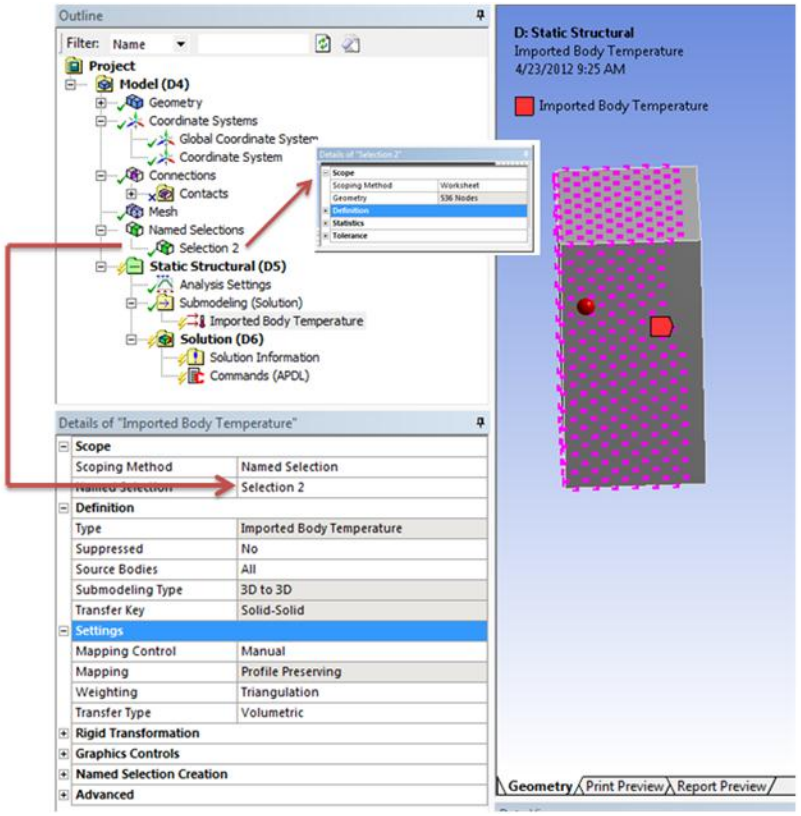
Mapped Data is displayed

Support for scale, offset, multiple load steps via worksheet



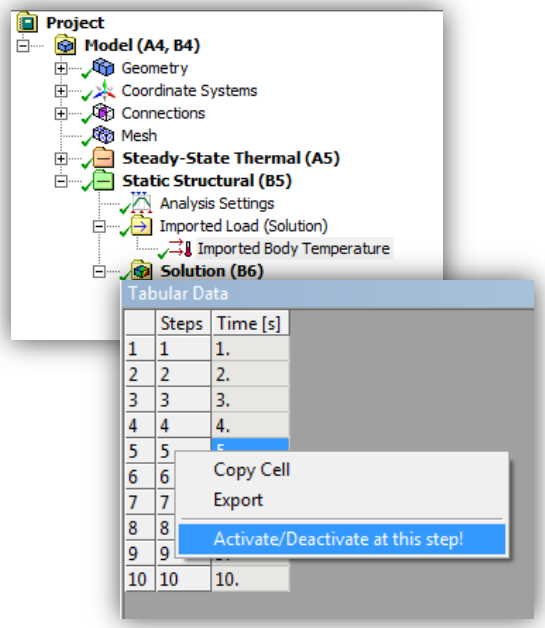
Scoping entities

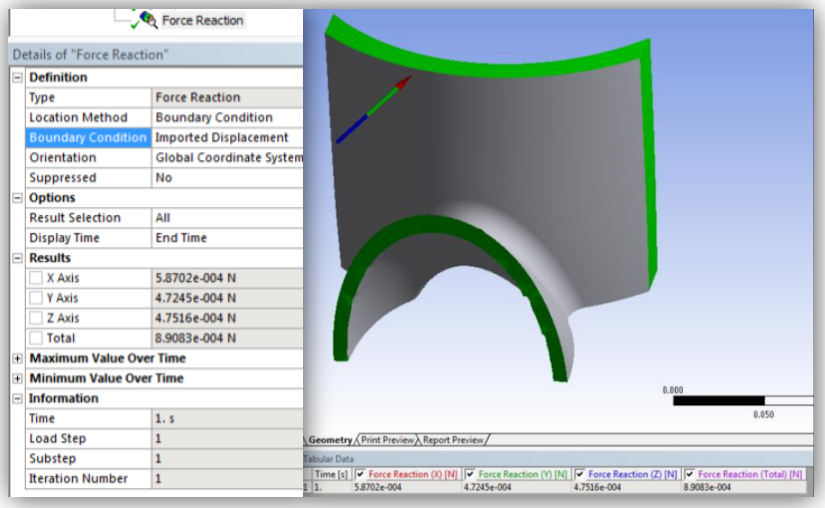
- **Node to Node Load import**: import data on nodes (displacement, force, and temperature) can be scoped to **node-based Named Selections**
- **Temperature and Displacement loads** can be scoped also to all geometry entity types (body, face, edge, or vertex).



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



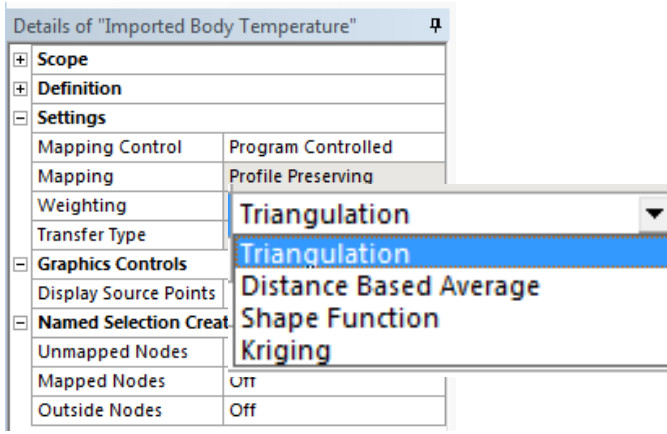


What's under the hood:

Weighting Options

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*

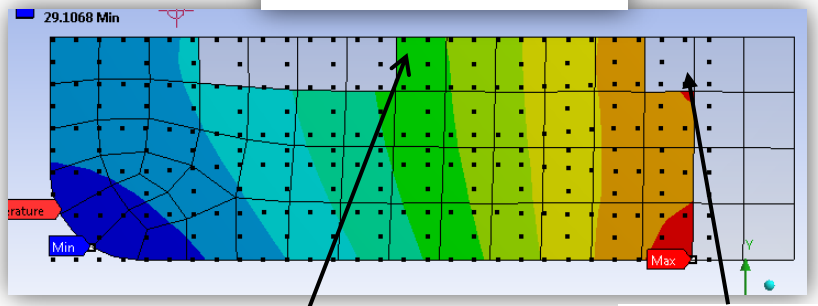
Triangulation

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

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

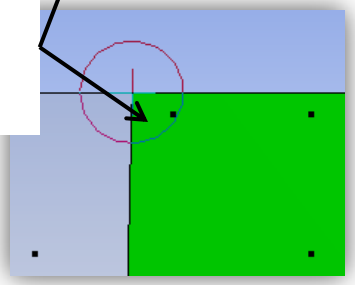
- **Pinball region** filter for closest source point;
- **Limit** the number of nearby points considered for interpolation;
- **Ignore** outside points
- Thickness offsets (target surface)

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



Node outside but within limit of 3mm

Nodes far outside

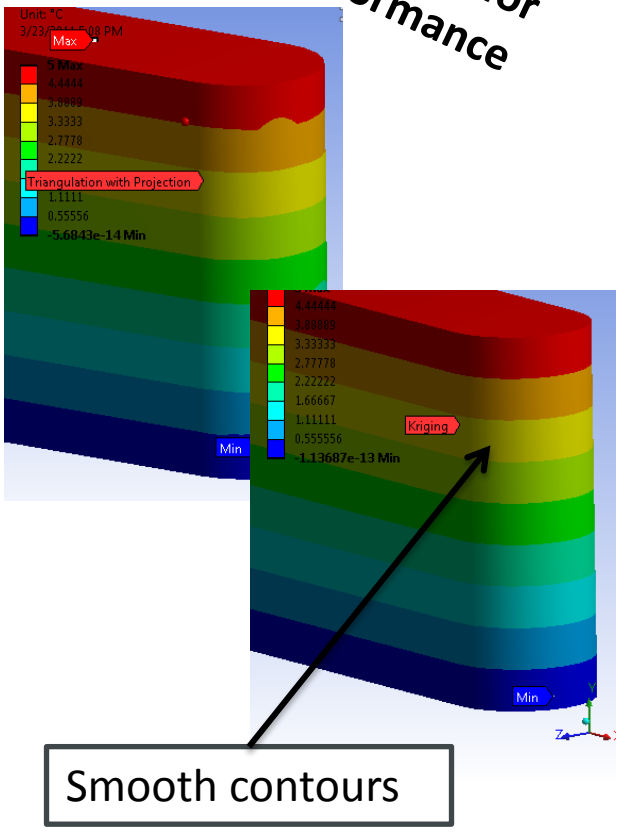


Zoomed in

Kriging

- **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: c**hange the mathematical function that is used to globally approximate the sample

Completely Parallelized for fast mapping performance



Shape Function – .CDB element data

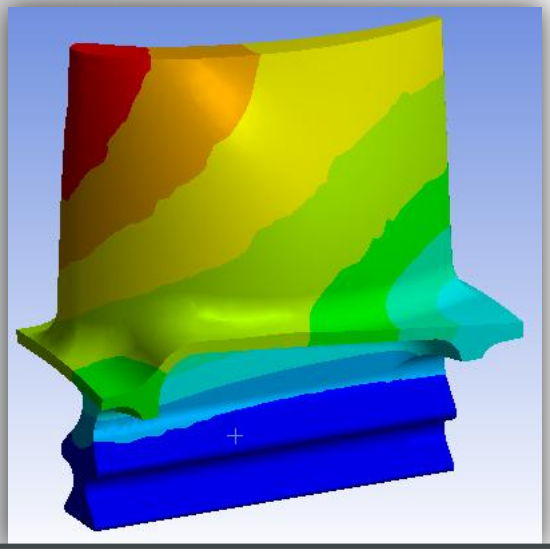
- External Data System now allows MAPDL CDB format to be selected allowing for nodal and element connectivity information to be provided to the mapping tool.

Schematic A2: Setup Schematic A2 : External Data

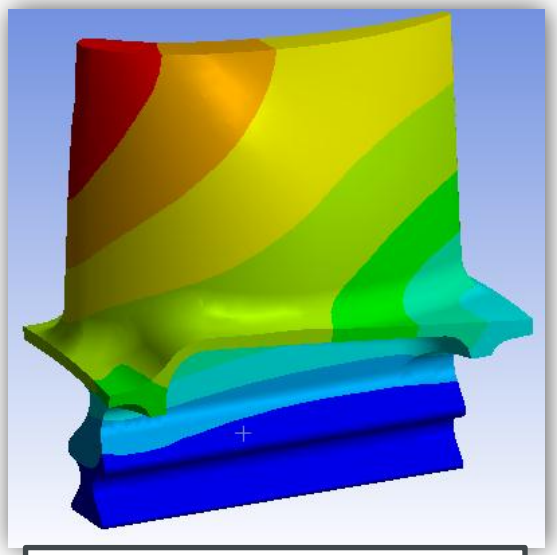
	A	B	C	D
1	Data Source	Location	Identifier	Master
2	D:\R14.5\Cup Analysis_files\import_files\cup.cdb	...	File1	☑
3	D:\R14.5\Cup Analysis_files\import_files\temperature.txt	...	File3	☐
*	Click here to add a file	...		

Properties of File - D:\R14.5\Cup Analysis_files\import_files\cup.cdb

	A	B	C
1	Property	Value	Unit
2	⊟ Definition		
3	Dimension	3D	
4	Format Type	MAPDL CDB	
5	Length Unit	m	

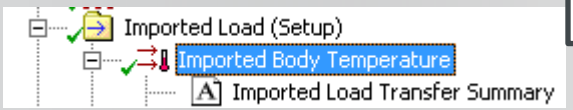


Temperature mapping using triangulation (Nodes Only)



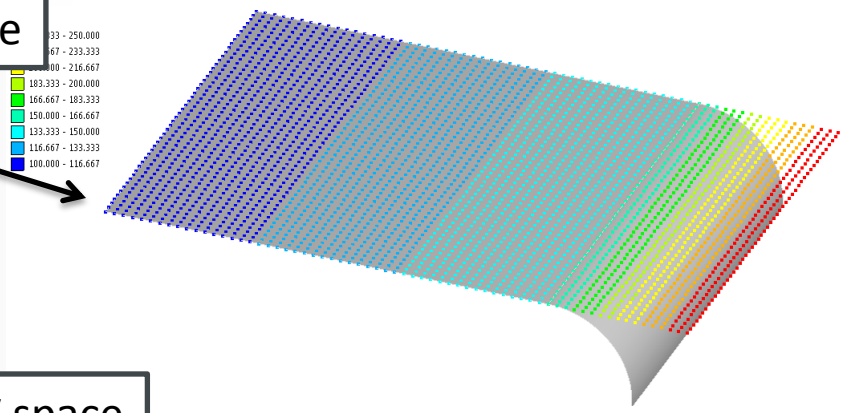
Temperature mapping using shape functions

New ‘UV’ option for imported loads (R15)

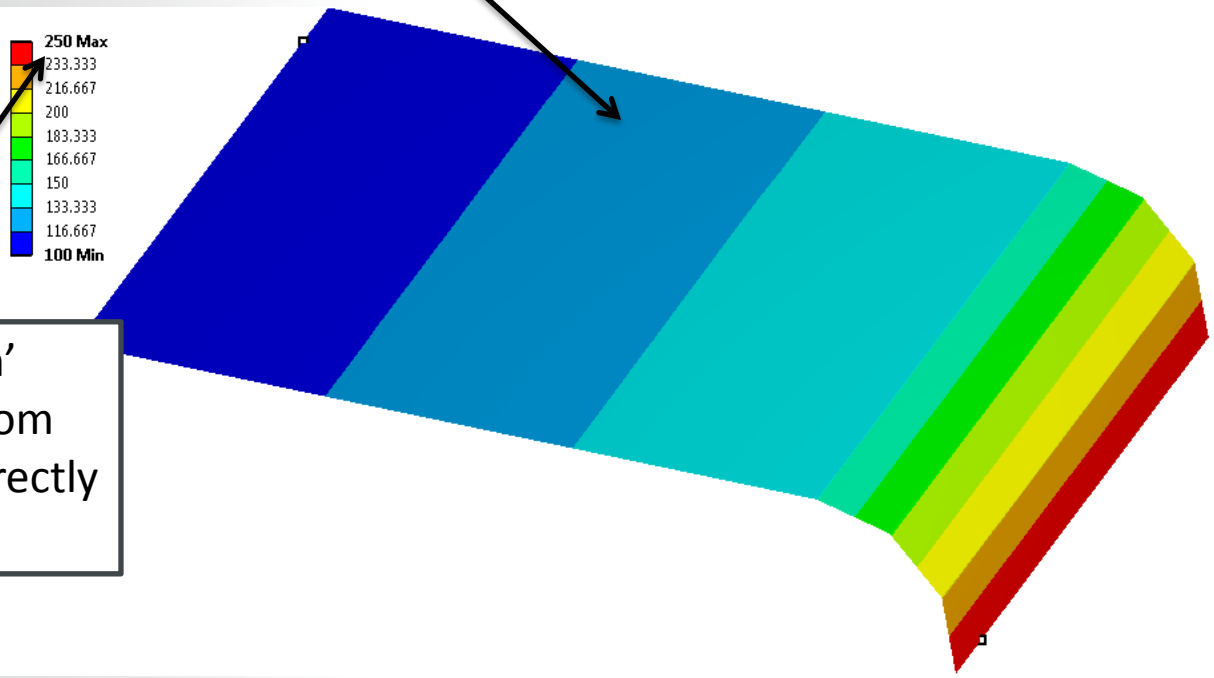


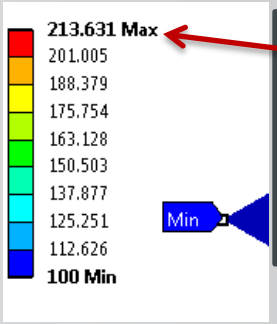
Settings	
Mapping Control	Manual
Mapping	Profile Preserving
Weighting	UV (Beta)
Graphics Controls	
Legend Controls	
Named Selection Creation	
UV Source Controls	
Alignment	Program Controlled
Coordinate System	Global Coordinate System
UV Target Controls	
Alignment	Program Controlled
Coordinate System	Global Coordinate System

Source data in plane



Mapped in UV space

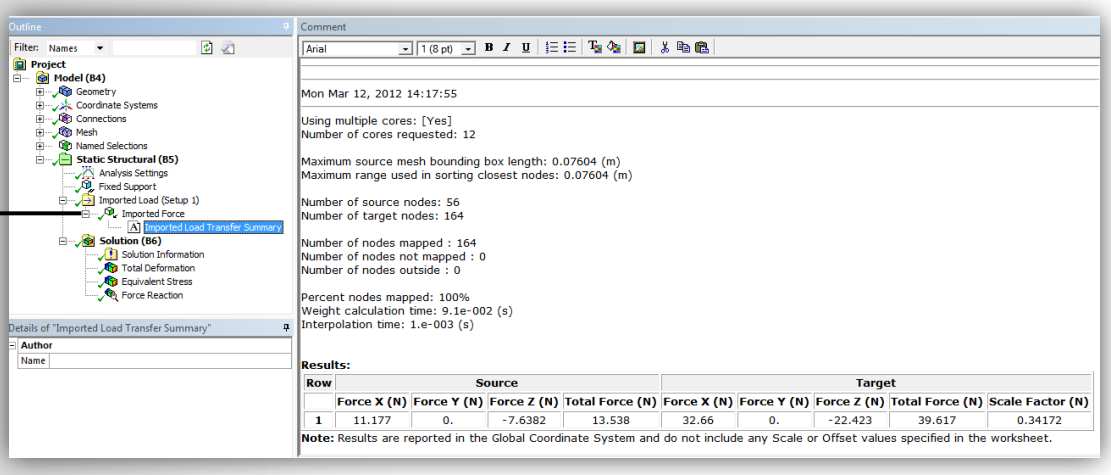


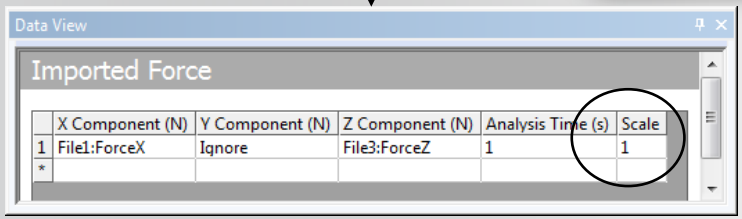


Using ‘Triangulation’ generates results from 100 to 213. UV correctly maps to 250!

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.

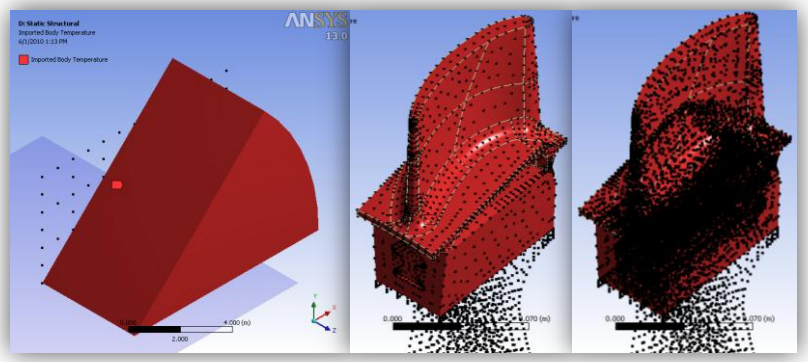


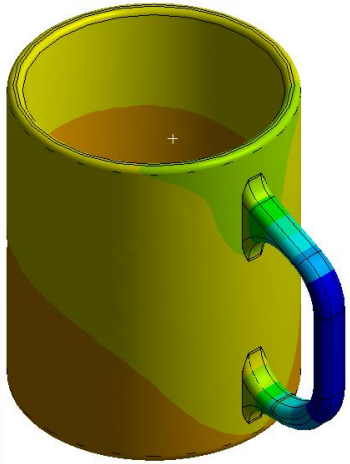


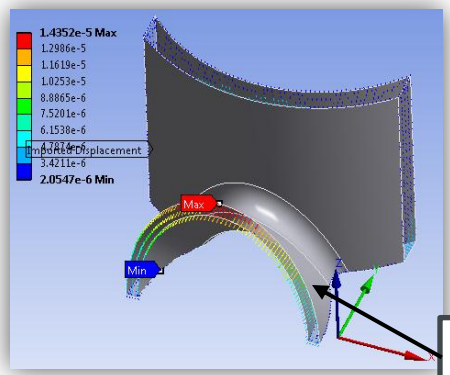
Validation & Diagnostics

Visualize Mapped Data

- **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



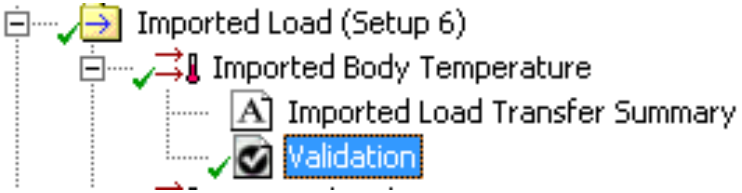


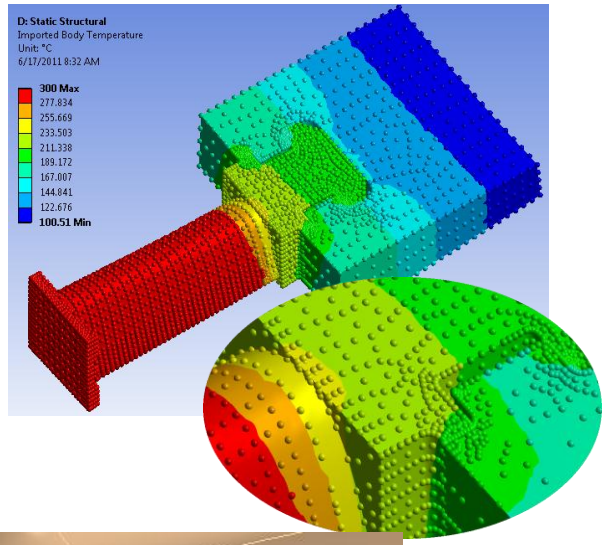


All vectors plot

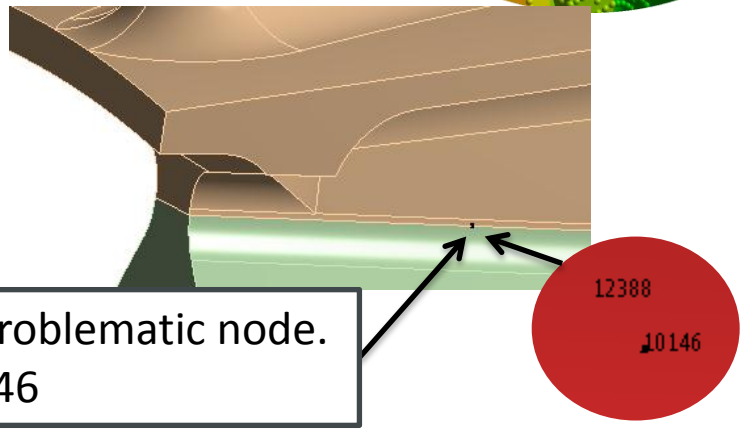
Validation Object

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

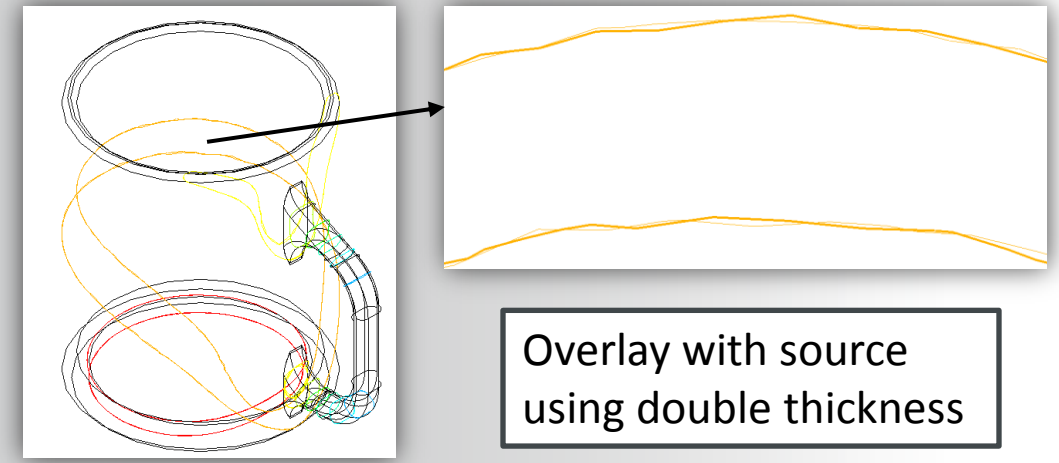


Overlay with node ids turned shows problematic node. The file does not contain data for 10146

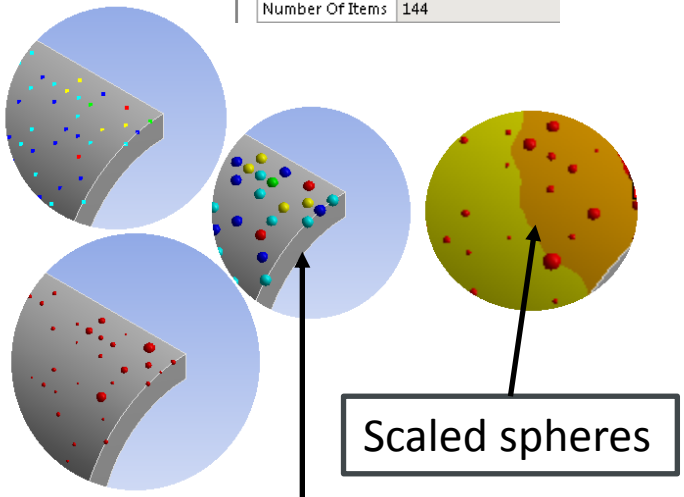
Validation Graphic Controls

- **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*

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

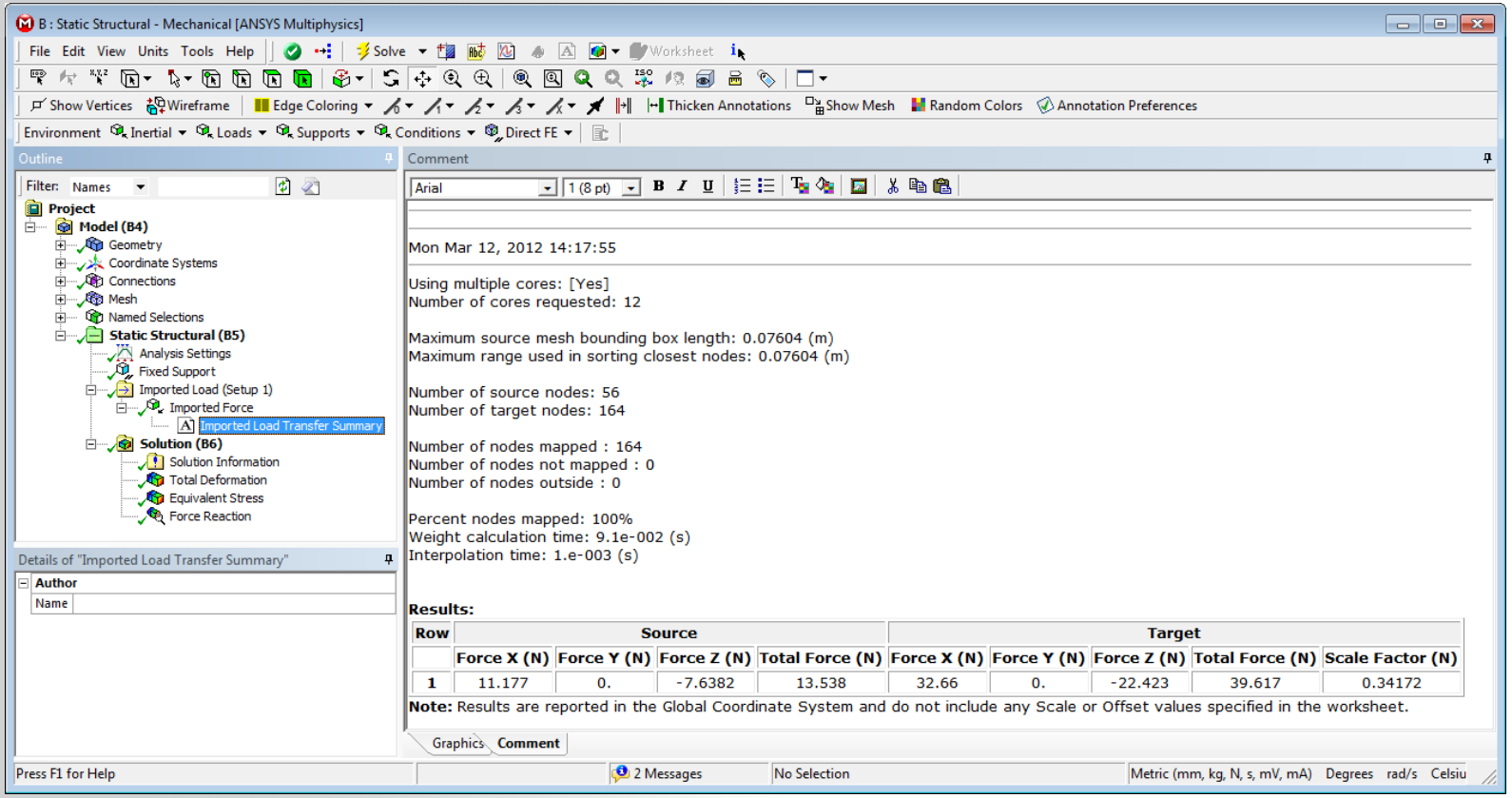


Overlay with source using double thickness



Diagnostic Information

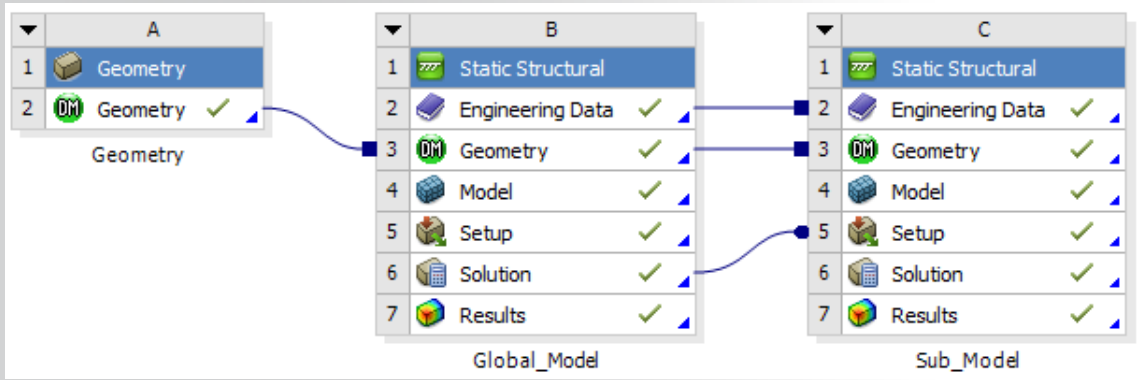
- **After mapping is completed, diagnostic information is output to give additional details about the mapping**

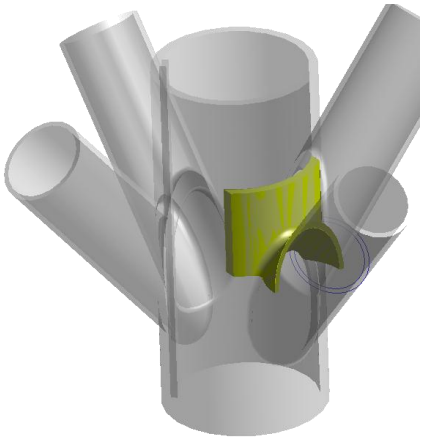


Some more sophisticate examples of data mapping

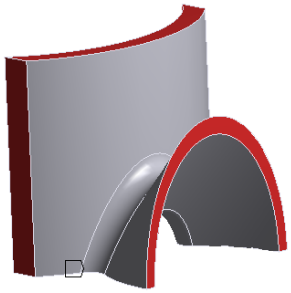
Introduction to Submodeling

- 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.



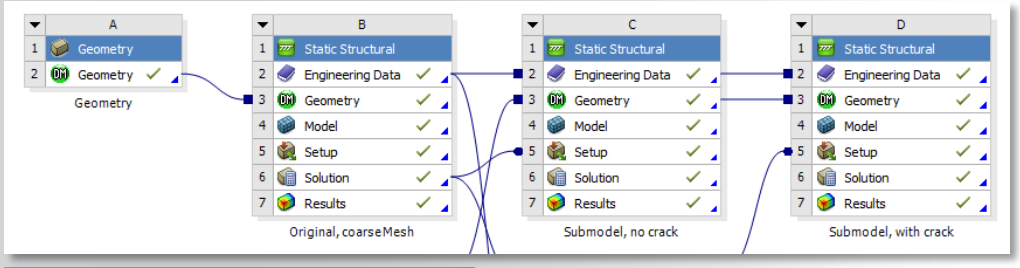


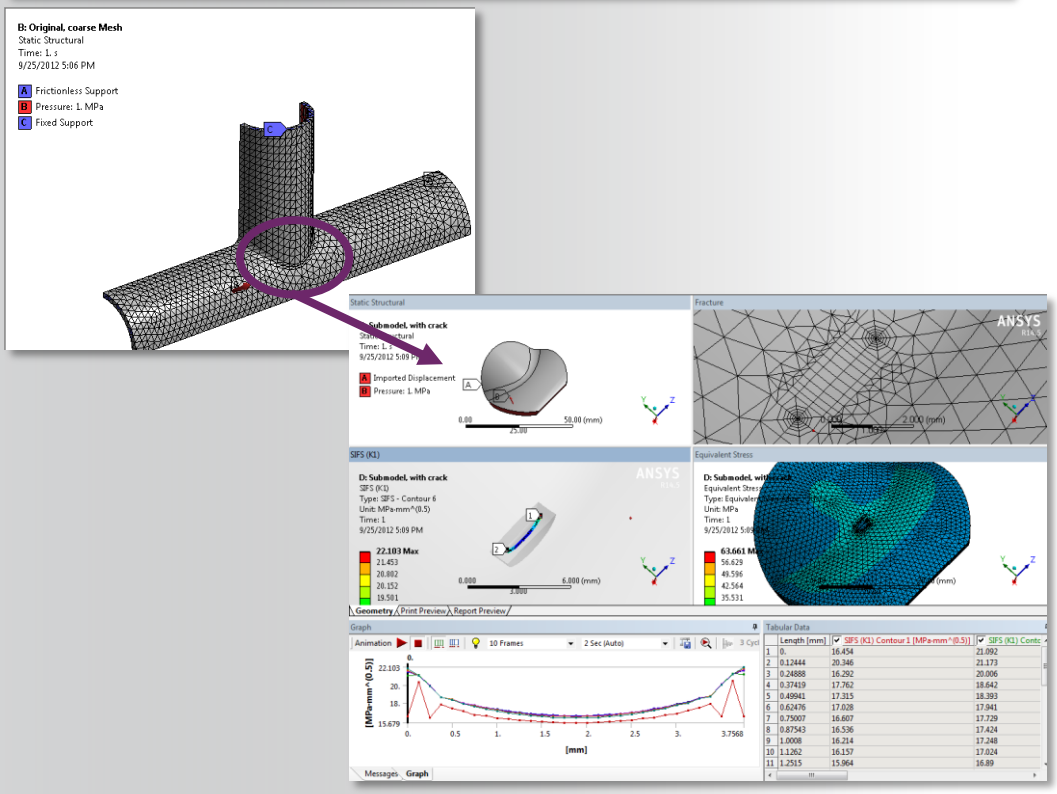
Global Model



Sub Model

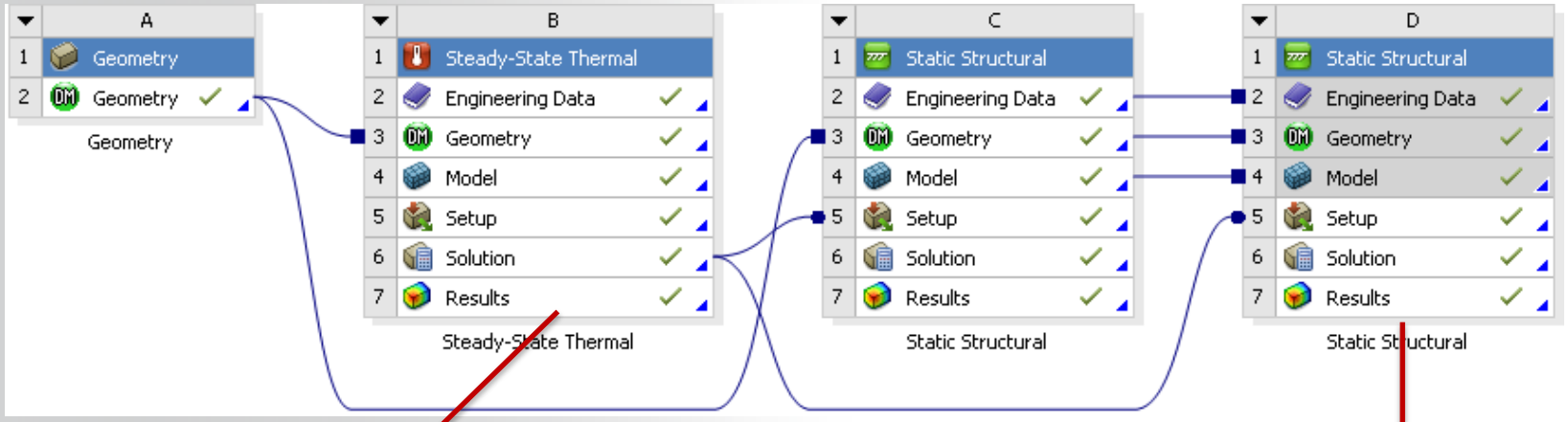
Example Application – Fracture



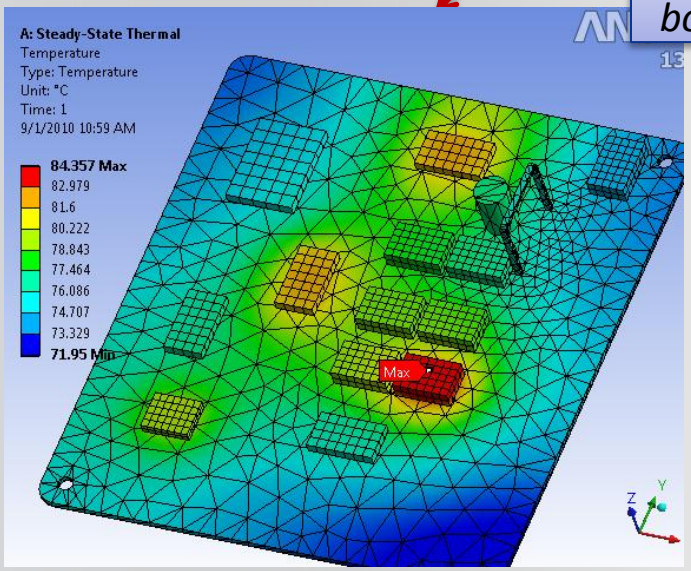


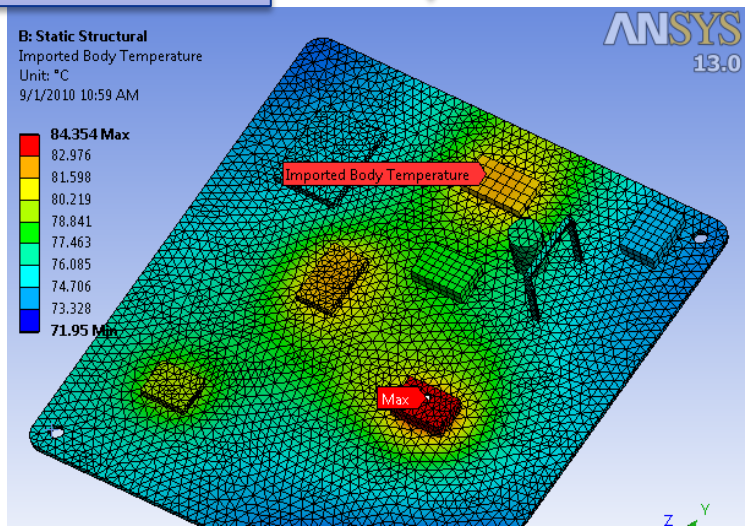
A crack can be introduced in a submodel to reduce overall computation time while increasing the local accuracy.

E.g. Thermal-Stress Analysis

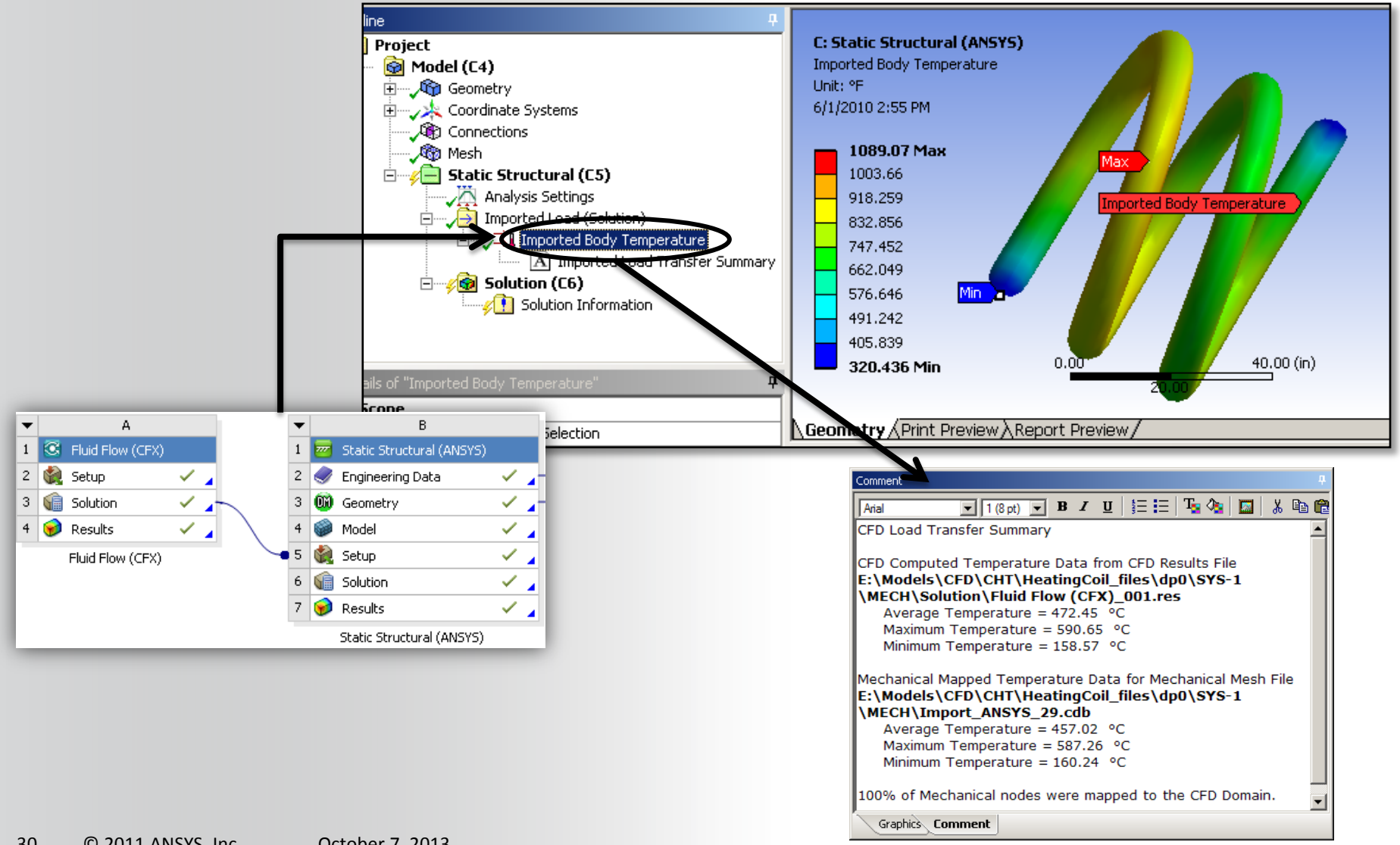


Automatically Handle 'scoping' to prevent **bleed *across*** *body boundaries.*



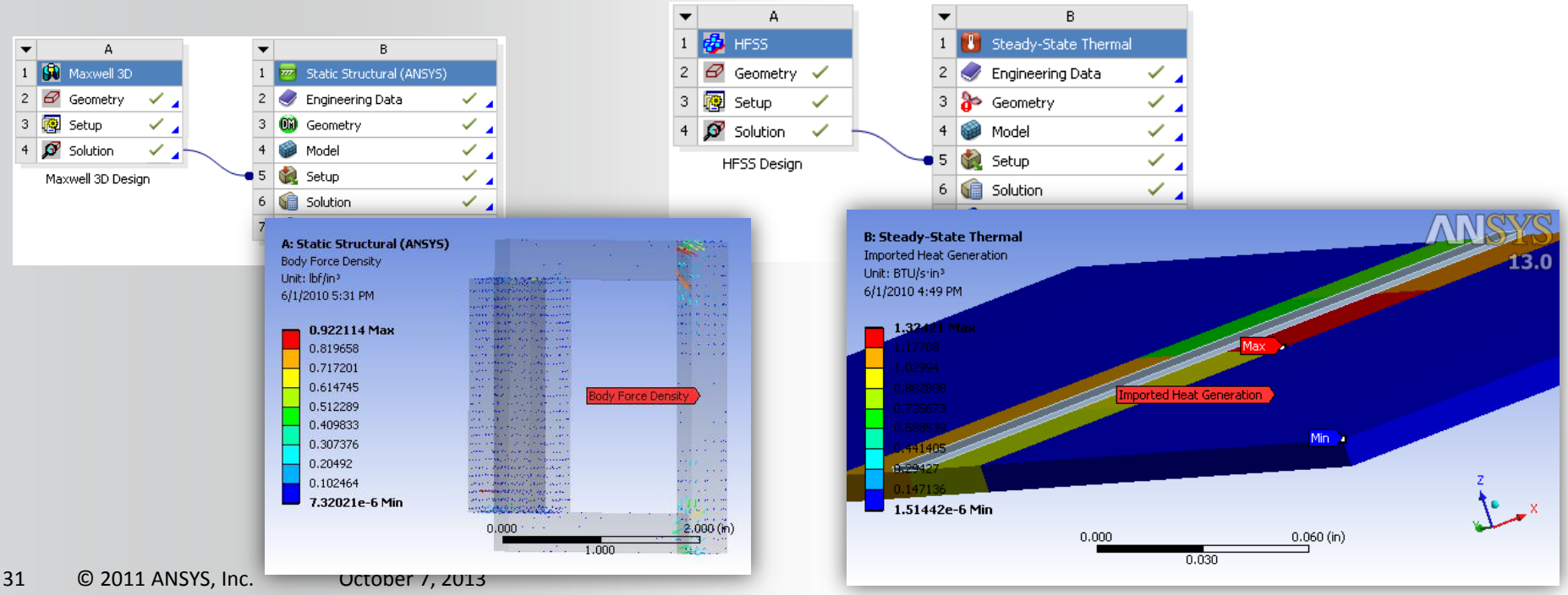


CFD to Mechanical Volumetric Temperature Transfer



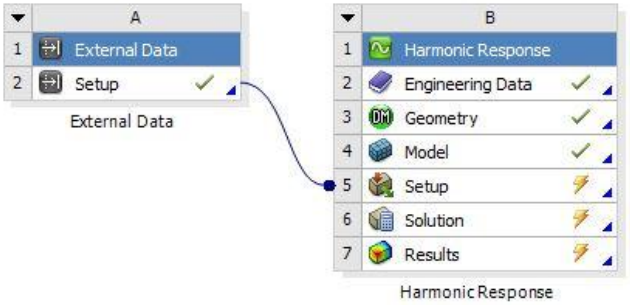
E.g. Mechanical – Maxwell/HFSS

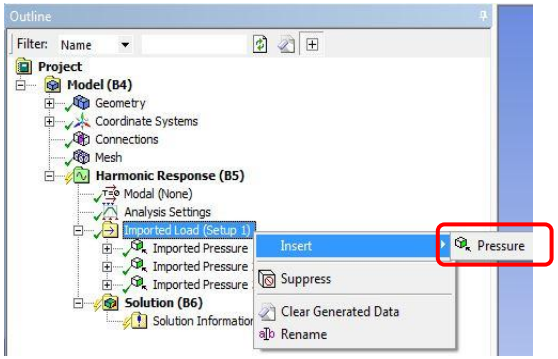
- **From Maxwell/HFSS:** Import Heat Generation/Heat Flux to Mechanical
- **From Mechanical:** Export Thermal Results to Maxwell/HFSS
- **From Maxwell:** Import Surface/Body Force Densities to Mechanical



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

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