

## Appendix O

A thermal/structural mapping tool for thermo-elastic distortion  
analysis

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### **Abstract**

As thermal and structural models become larger and more complex, the labour involved in mapping temperatures from thermal to structural models has naturally increased. This presentation describes a method that has been developed to aid the process of temperature mapping to structure models for thermo-elastic distortion. The process is centred on a mapping tool that allows the semi-automatic mapping of temperature data to structure models, independent of analysis software, thus reducing the hours required for this task. The presentation will provide an overview of the key aspects of the process, issues that may arise, their solution and potential future developments.

# Thermal-Structural Mapping for Thermo-elastic Distortion Analysis

A Semi-Automated Mapping Process for Thermal/Structural Models

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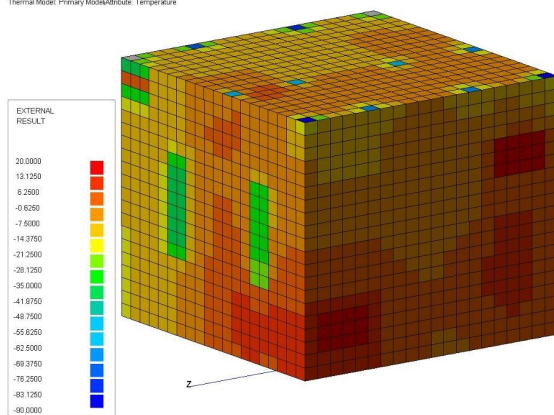


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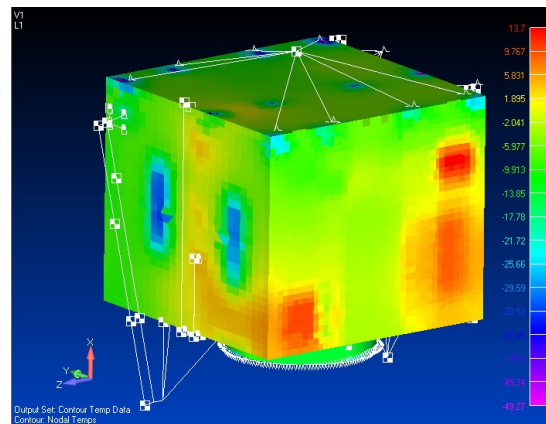
## What is TED Mapping?

- Application of thermal model data to a mechanical model to allow the prediction of thermo-elastic distortion effects

Thermal Model: Primary Model Attribute: Temperature



Thermal Model



Mechanical Model

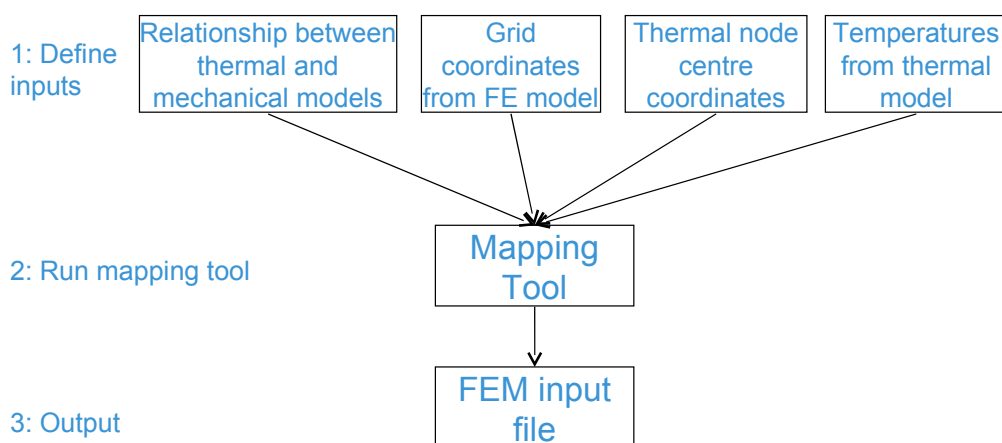
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## Why Develop This Tool?

- Not reliant on Commercials Off The Shelf Software (COTS) i.e. PATRAN or IDEAS which current processes depend on
- Mapping is performed and therefore controlled and owned by thermal community as opposed to mechanical
- Inputs to the semi-automated process:
  - Thermal model geometry from ESARAD
  - Mechanical model geometry from FE model
  - Predicted temperatures from ESATAN
- Output:
  - An file suitable for import into FE modelling software containing temperatures linked to FEM grid number

## The Process



## Define Mapping Relationship

- Relates groups of thermal nodes to groups of mechanical model grids
- Define groups according to
  - Homogenous material
  - Continuous geometry
- Groups can have differing names in mechanical and thermal input files
- Format
  - *Thermal Group Name, Mechanical Group Name*

```
PY_External_Panel, PY_External_Panel  
STR_bracket, Star_Tracker_bracket
```

## Generate FEM Grid Positions

- Positions of grids in mechanical model to be mapped
- Cartesian coordinates exported from analysis software based on the s/c coordinate reference frame
- Format
  - *Group\_Name, Grid\_ID, x, y, z*

```
Separation_Ring,200001,0.345189,0.201308,0.0042  
Separation_Ring,200002,0.33888,0.211756,0.0042  
Separation_Ring,200003,0.331283,0.223454,0.0042
```

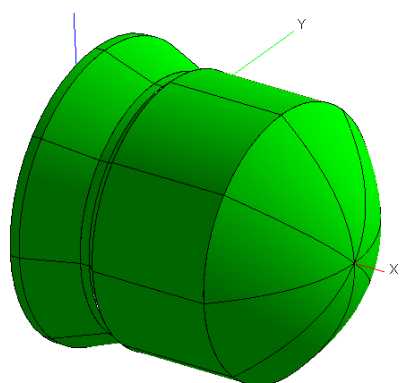
## Thermal Node Centre Positions

- Need the coordinates of thermal model shells in spacecraft coordinates
  - Export ESARAD geometry file (.erg)
  - Use TASverter to convert .erg file to .SYSBAS file (suitable for Thermica)
  - Import .SYSBAS file into Thermica
  - Export geometry in universal file format (.unv)
- Format
  - *Group\_Name, Grid\_ID, x, y, z*

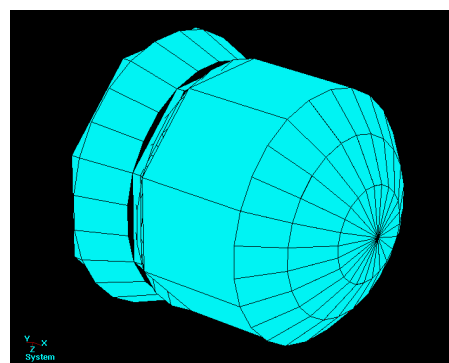
```
16101,LOWER_CLOSURE_PANEL,0.394667,-0.190500,0.121500
16101,LOWER_CLOSURE_PANEL,0.394667,-0.190500,0.121500
16101,LOWER_CLOSURE_PANEL,0.394667,-0.190500,0.121500
```

## Generate Thermal Node Centres

- Complex shells in ESARAD split into many shells by TASverter during conversion to .SYSBAS



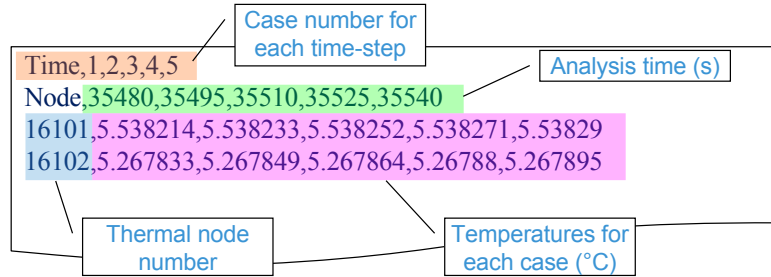
ESARAD



Thermica

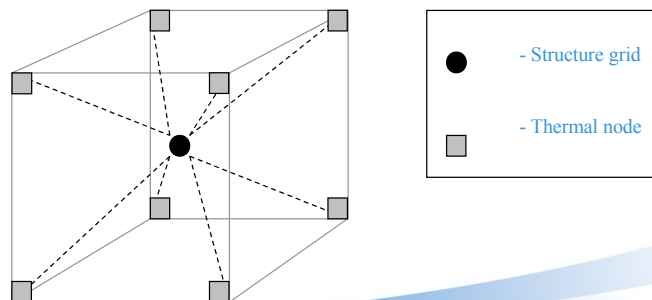
## Temperature History

- Extracted from the results of the thermal analysis for the relevant case
- Can contain steady-state or transient data



## The Mapper

- Performs linear interpolation in three dimensions between relevant thermal nodes to calculate grid point temperature
- Area surrounding each node divided into eight regions (+x+y+z, -x+y+y, +x-y+z.....)
- Thermal node closest to the FEM grid in each region used for interpolation



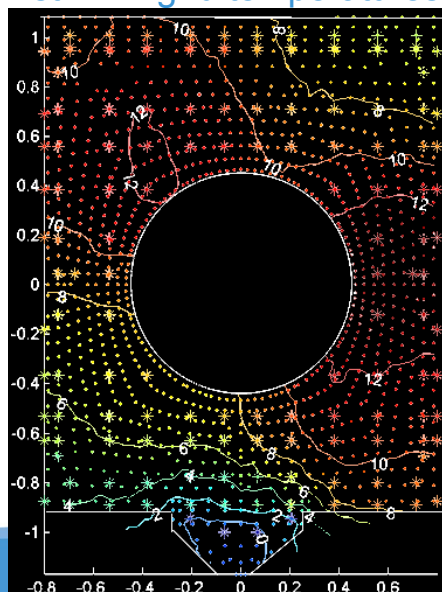
## The Mapper

- Results can be interrogated to look at individual or multiple groups and time-steps
- Very quick to run
- Produces output file suitable for import into FEM software, e.g. Nastran

```
TEMP,1,200001,-2.6054
TEMP,1,200002,-2.5946
TEMP,1,200003,-2.5563
```

## The Mapper

- Visualiser can be used to check temperatures in the thermal model against FEM grid temperatures



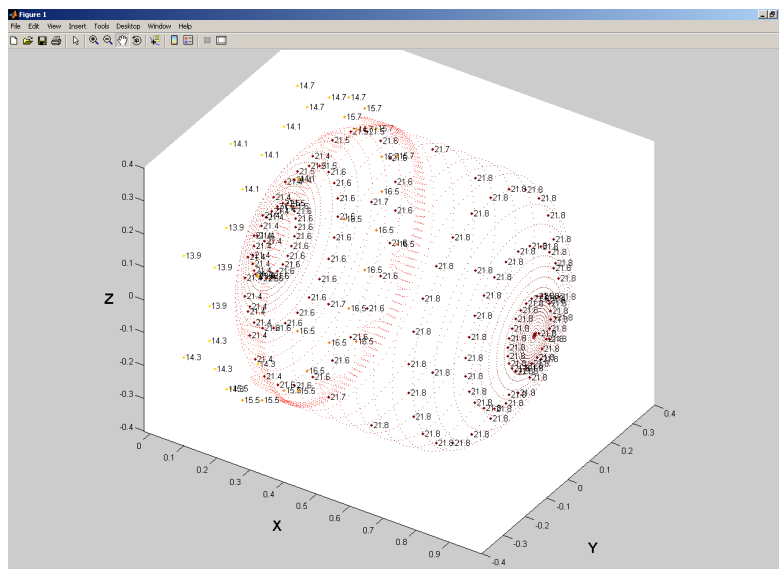
```
* - Thermal node
· - FEM Grid
```



## Future Developments

- **Groups**
  - Mapping of many groups to one group
- **Recognition of complex boundaries**
  - Non-uniform discontinuities, for example panel edges, currently need to be mapped using targeted groups
- **Visualiser**
  - Further development of MATLAB as a post-processing tool, e.g 3-D contour plots

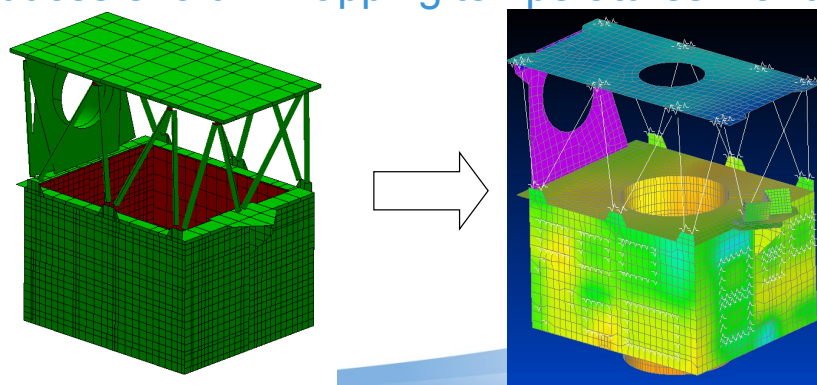
## Future Developments



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## Recap

- Easy to use
- Provides a good match between thermal and FE model temperatures
- Reduces effort in mapping temperatures manually



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The logo for EADS ASTRIUM, featuring the word "EADS" in a bold, sans-serif font above the word "ASTRIUM" in a smaller, spaced-out font. A stylized blue and orange graphic element is positioned to the right of the text.