

Appendix S

ESATAN Thermal Modelling Suite Product Developments and Demonstration

Chris Kirtley Nicolas Bures
(ITP Engines UK Ltd, United Kingdom)

Abstract

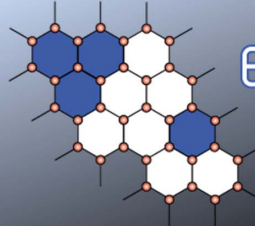
Product Developments

ESATAN-TMS provides the Engineer with a complete and powerful integrated thermal modelling environment. Version r6 was released at the end of last year and saw a significant evolution in its modelling capability. 3D solid geometry can now be modelled, performing ray-tracing on solid surfaces and allowing selection of either lumped parameter or finite element thermal analysis on the solid structure. With ESATAN-TMS r7 the focus of work of this release has been on a number of areas, including a tighter integration between Workbench and ESATAN, improvements to the layout of the user interface and general improvements directly raised by our customers.

This presentation outlines the new features to be included in the next release of ESATAN-TMS.

Thermal Modelling Demonstration

A demonstration of the new features included in ESATAN-TMS r7 will be given, building a thermal model to demonstrate the new functionality.

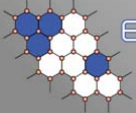


ESATAN-TMS
thermal modelling suite

ESATAN-TMS Product Overview

Chris Kirtley

28th European Thermal & ECLS Software Workshop
ESA/Estec, Noordwijk, the Netherlands

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Introduction

- Major evolutions of the product

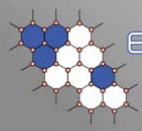


2011 2012 2013 2014

r3 r4 r5 r6

- Improved Import of CAD Geometry
- Combined FE / LP Analysis**
- Enhanced Model Tree Component
- New Conjugate Gradient Thermal Solver
- Contour Plotting
- Extension of Post-processing (ThermNV)
- Post-processing ThermNV derived data
- User-defined Feature Requests
- Performance & Scalability

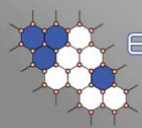
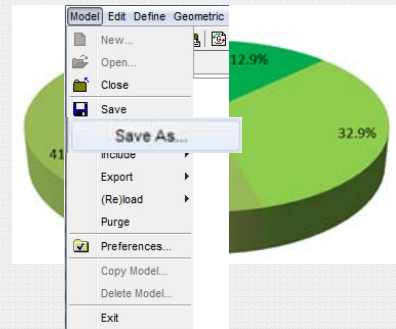
- Modelling of Solid geometry**
- Radiative Cavities
- New Visualisation**
- Multiple selection
- Transparency
- New clipping plane
- Non-regular mesh support



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Introduction

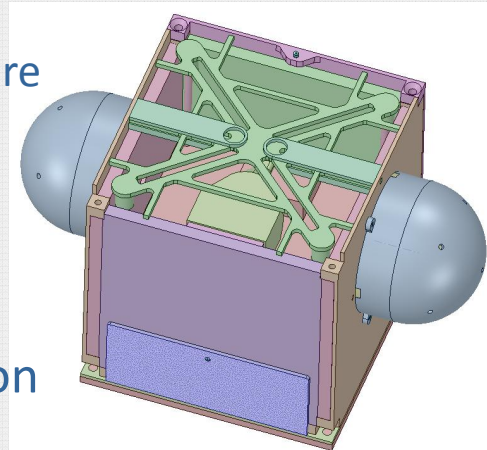
- User survey performed at the end of 2013
 - Feedback on how we are doing
 - Product functionality
 - Quality of user support
 - **What's important to you**
- Continued **major investment** on the product
- Focusing on points you raised
- Now finalising release for the end of the year

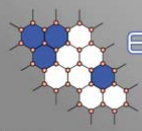


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Contents

- Presentation of ESATAN-TMS development status
 - Model import from CAD
 - Further thermal integration
 - Improved user interface
 - Modelling time & temperature dependency
 - Model definition
 - Simplified user input
- Followed by a demonstration

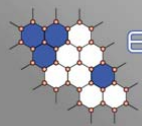
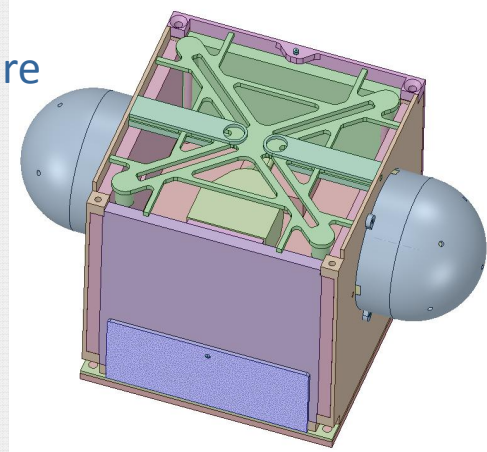




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Contents

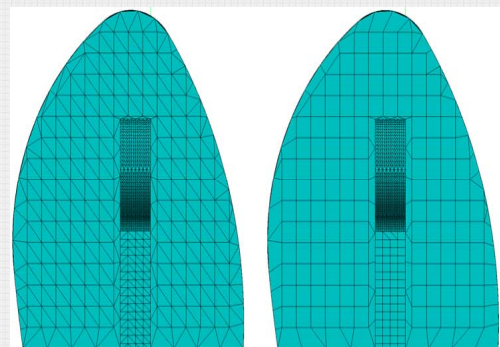
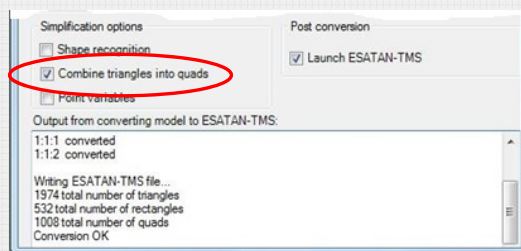
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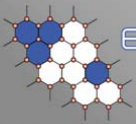


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Model Import from CAD

- CADbench 2014 development
 - User feedback on conversion of CAD models
 - Handle more cases recognising primitives
 - Option to merge triangular element into quads
 - Merge triangles which are planar within a tolerance

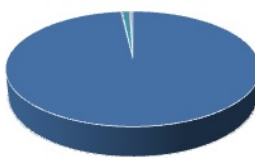




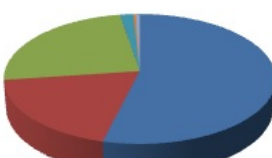
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Model Import from CAD

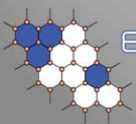
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 - User feedback on conversion of CAD models
 - Handle more cases recognising primitives
 - Option to merge triangular element into quads
 - Merge triangles which are planar within a tolerance



Primitive	Percentage
Triangles	98.18%
Rectangles	0.17%
Quads	0.007%
Spheres	0.026%
Cylinders	1.09%
Discs	0.17%
Cones	0.33%



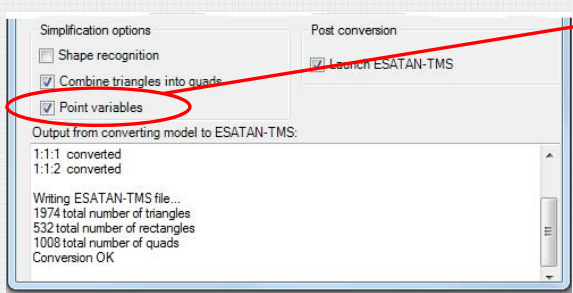
Primitive	Percentage
Triangles	53.9%
Rectangles	18.95%
Quads	24.49%
Spheres	0.04%
Cylinders	1.77%
Discs	0.335%
Cones	0.5%



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Model Import from CAD

- CADbench 2014 development
 - Option to generate Point Variables
 - Dynamic binding of geometry
 - Literal points reduces model complexity



Simplification options

☐ Shape recognition

☒ Combine triangles into quads

☒ Point variables

Post conversion

☒ Launch ESATAN-TMS

Output from converting model to ESATAN-TMS:

1:1:1 converted

1:1:2 converted

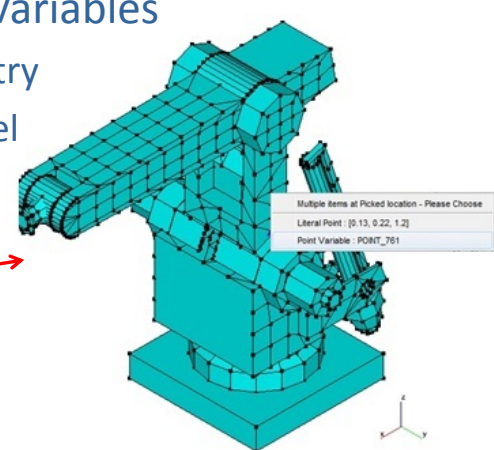
Writing ESATAN-TMS file...

1974 total number of triangles

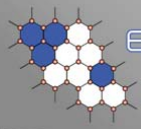
532 total number of rectangles

1008 total number of quads

Conversion OK



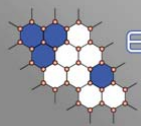
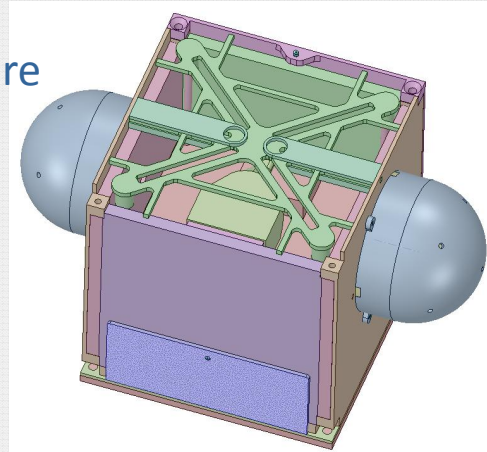
Item	Name	Coordinate
Point	POINT_125	[0.62281, 0.15, 1.6]
Point	POINT_138	[0.73098, 0.15, 1.6]
Point	POINT_572	[0.23, 0.22, 1.94321]
Point	POINT_552	[0.23, 0.22, 1.2]
Point	POINT_763	[0.13, 0.22, 0.98518]



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Contents

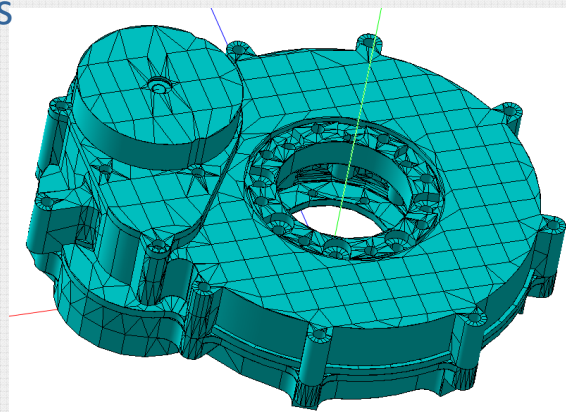
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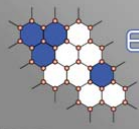


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Thermal Integration

- Vision of an **fully integrated thermal modelling environment**
 - High-level thermal modelling through Workbench
 - Simplified interface, less error prone
 - Easier validation
 - More efficient
 - Availability of data
 - Consistency of data & concepts throughout

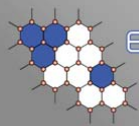




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Thermal Integration

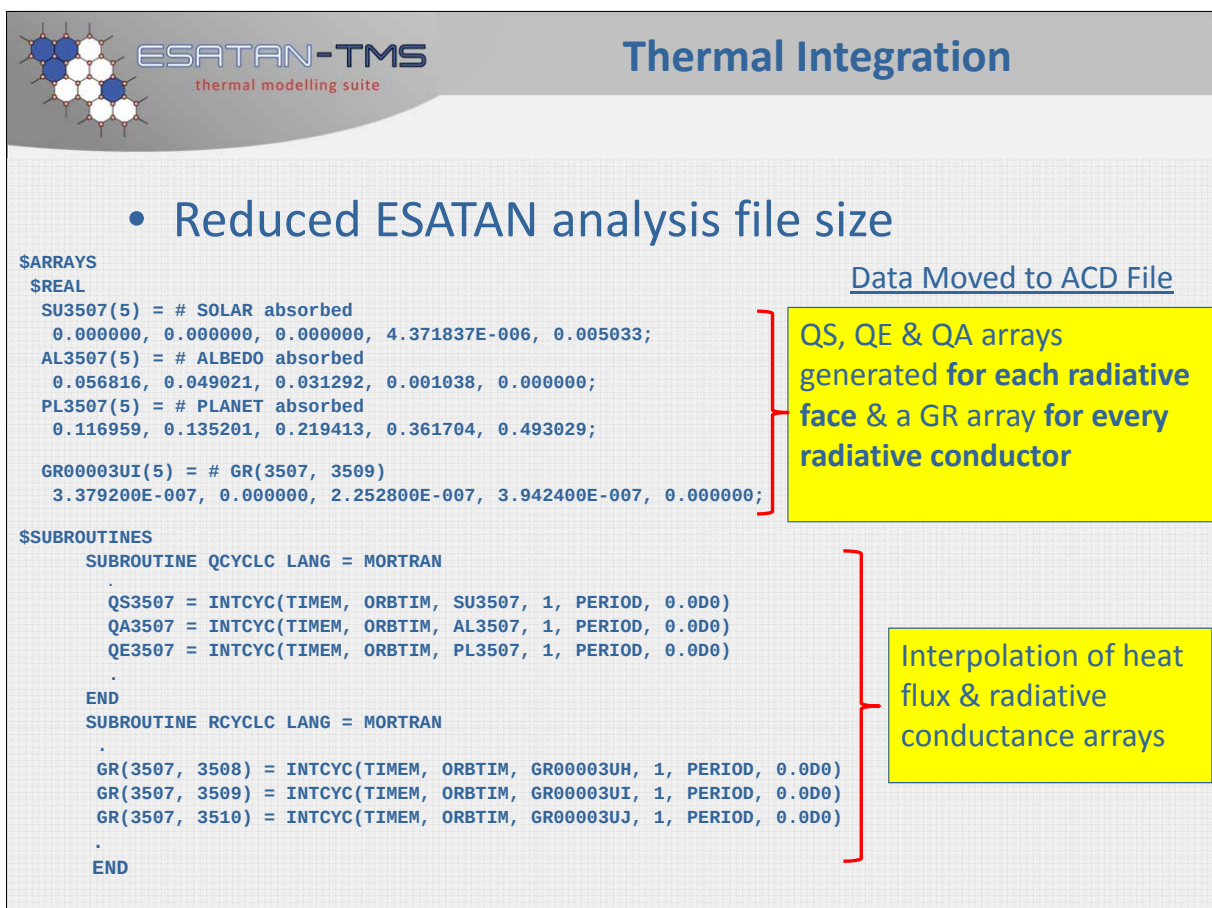
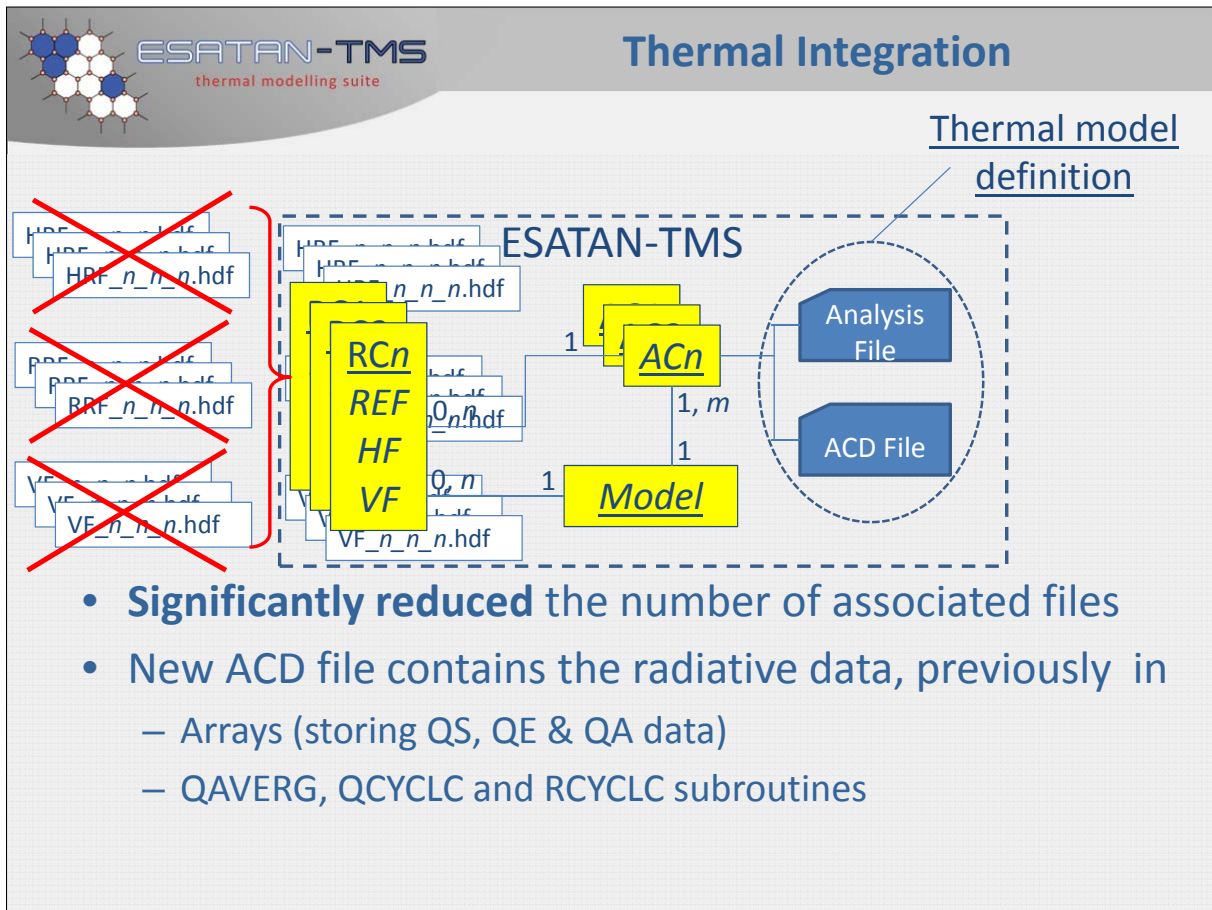
- Handling of Radiative Data (GRs & Qs)
 - Large number of generated radiative conductors
 - Data generated for each orbit position
 - Particularly models with moving geometry
 - Can lead to significant processing time
 - Data handling within Workbench
 - Exporting ESATAN analysis file
 - ESATAN Pre-process, compile, link & solve
 - In some cases file system or compiler limits reached

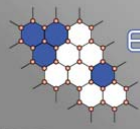


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Thermal Integration

- In r7, redesigned storage of REF, VF, HF data
- Introduce **option** to write radiative data directly to a new ESATAN data file
 - Introduce **Analysis Case Definition (ACD) file**
 - ACD file goes hand-in-hand with ESATAN analysis file
 - Store radiative (GR & Q) data in ACD file
 - Node & conductor definitions retained in analysis file
 - ACD file uses HDF5 format
 - Platform independent binary file
 - Efficient structure & format

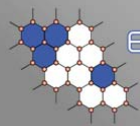




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Thermal Integration

- ACD data is automatically read by the solution
 - Static heat flux read at the start of the analysis
 - Transient heat flux & conductance
 - Read in \$VARIABLES1
 - Data only read into memory as required
 - Efficient interpolation of data
- Reminder, a full ESATAN analysis file can be generated if required



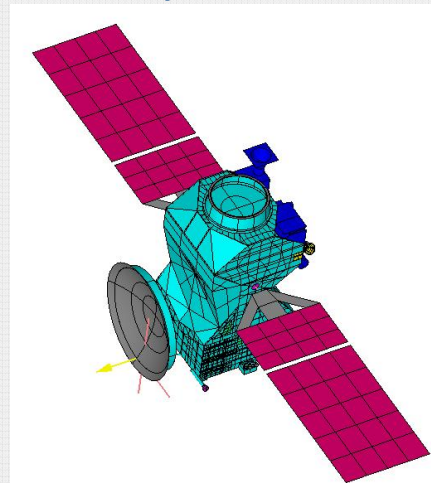
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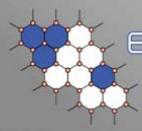
Thermal Integration

- Leads to **improved performance, reduced overall file size & reduction in memory**
- Example science model provided by OHB

Generated File Size (Mb)			
Data File	ESATAN-TMS		Δ (%)
	r6	r7	
Analysis File / ACD File	40	18	55%
MDB file	39	6	85%
Pre-processor log file	40	13	68%
Fortran file	15	6	60%
Model executable	18	5	72%
Total	152	48	68%

Performance (s)			
Process	ESATAN-TMS		Δ (%)
	r6	r7	
Pre-process	204	18	91%
Solution	133	67	50%
Total	337	85	75%

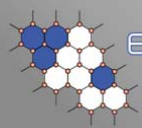




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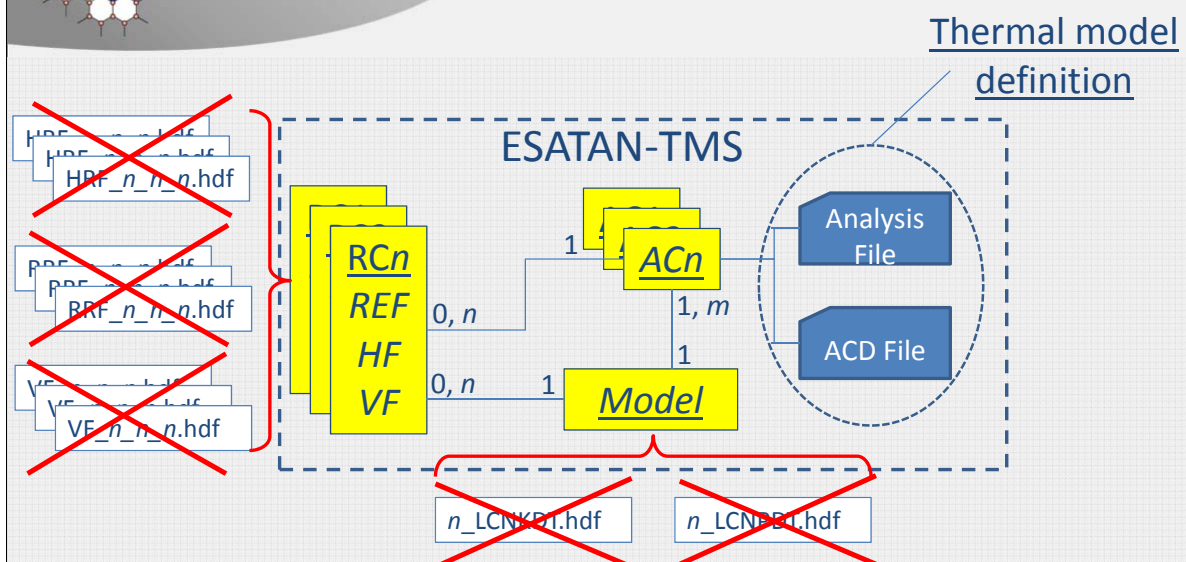
Thermal Integration

- In r7, handling of linear conductor data improved
 - Redesigned data storage within Workbench
 - Now store **all linear conductor data**
 - Previously stored only the LP conductors
 - Now store FE conductors and conductors generated from Contact Zones and User-Defined Conductors
 - Automatically calculate linear conductors on export to ESATAN, **only if they are out of date**

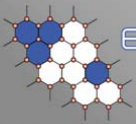


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Thermal Integration



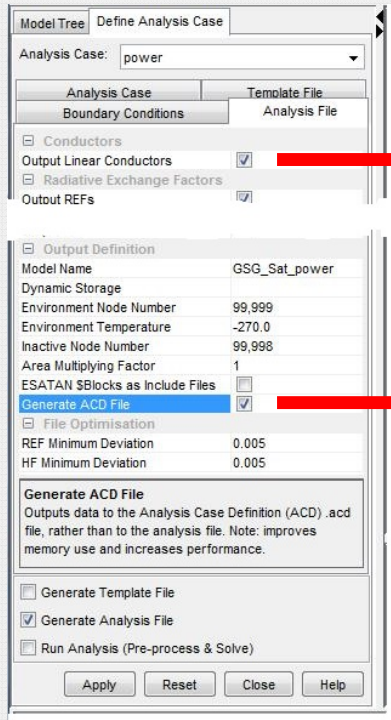
- Reduce the number of associated files
 - Linear conductors stored with the overall model data
- Now **store all conductor data**



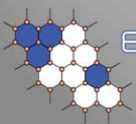
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Thermal Integration

Workbench GUI Changes



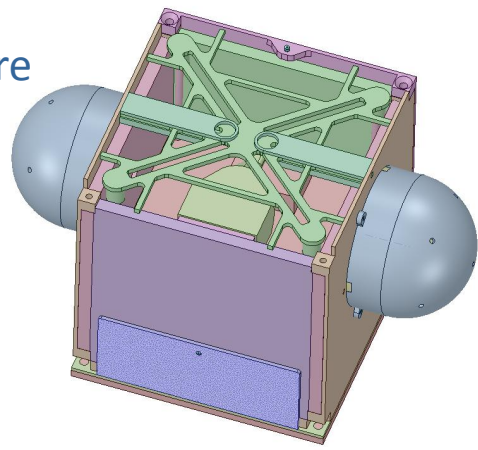
- Select to output **all linear conductors** (default)
- “Calculate Conductors” option removed
- **Option** to generate radiative data in Analysis Case Definition file (default)

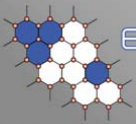


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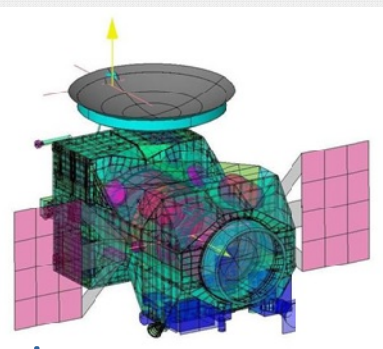


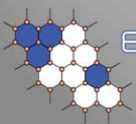


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Improved User Interface

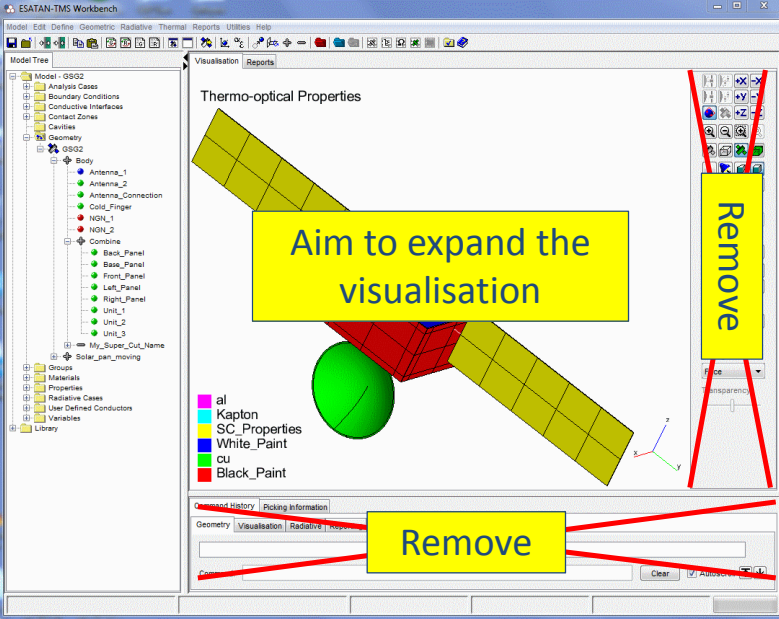
- ESATAN-TMS r6 saw a new visualisation
 - New visualisation technology
 - Take advantage of hardware
 - New functionality
 - Multiple selection, transparency & revised cutting plane
- Continue to build on this foundation
 - Improved user interface
 - More interactive model build
 - Pre- and post-processing of model data

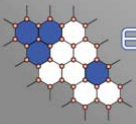




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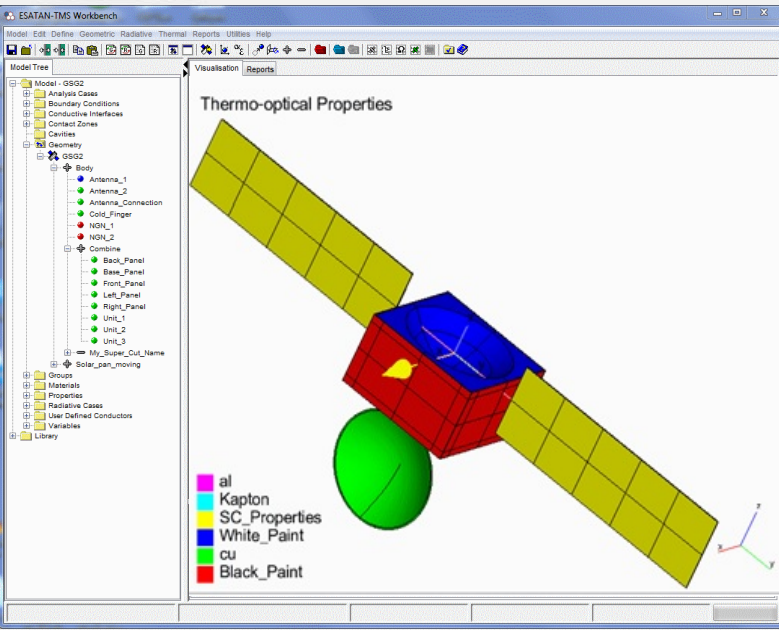
Improved User Interface





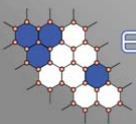
ESATAN-TMS
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Improved User Interface



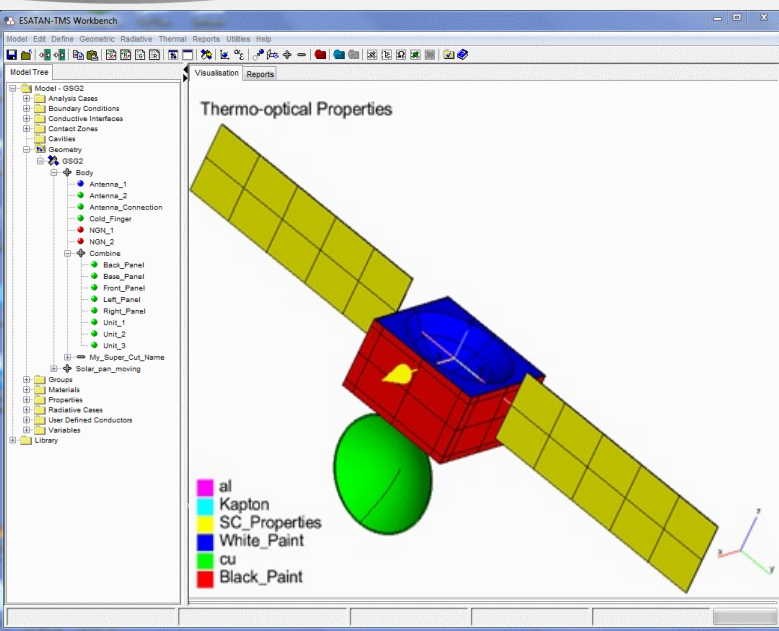
In r7 redesigned,

- Report Symbols
- Delete Environment
- Clipping Plane
- Include Model
- Custom Menu
- Report Case Results
- Process Conductor Interfaces
- Assembly
- Define Variables
- Cut / Combine
- Reporting Tab



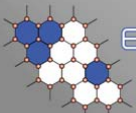
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Improved User Interface



In r7 redesigned,

- Report Symbols
- Delete Environment
- **Clipping Plane**
- Include Model
- Custom Menu
- Report Case Results
- **Process Conductor Interfaces**
- Assembly
- **Define Variables**
- Cut / Combine
- **Reporting Tab**



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Improved User Interface

Clipping Plane

Model Tree **Adjust Clipping Plane**

X Rotation: 0 180 360

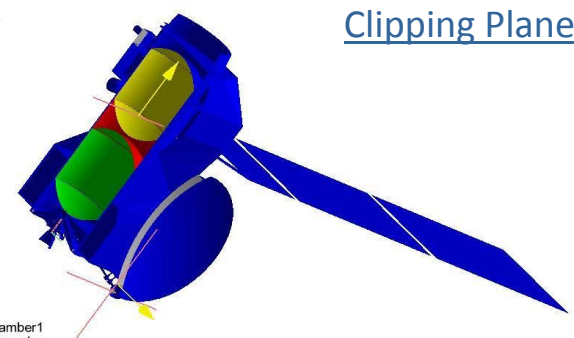
Y Rotation: 0 180 360

Z Rotation: 0 180 360

Distance: -6.74E0 0.0 6.74E0

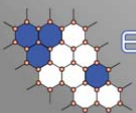
☒ Clipping plane on

Reset Close



■ Chamber1
■ External
■ Chamber2
■ InterChamber

- Introduced in ESATAN-TMS r6
- Redesign to a vertical dialog
- Very useful modelling tool
 - Inspect internal geometry
 - Visualise Radiative Cavities
 - Display internal results



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Improved User Interface

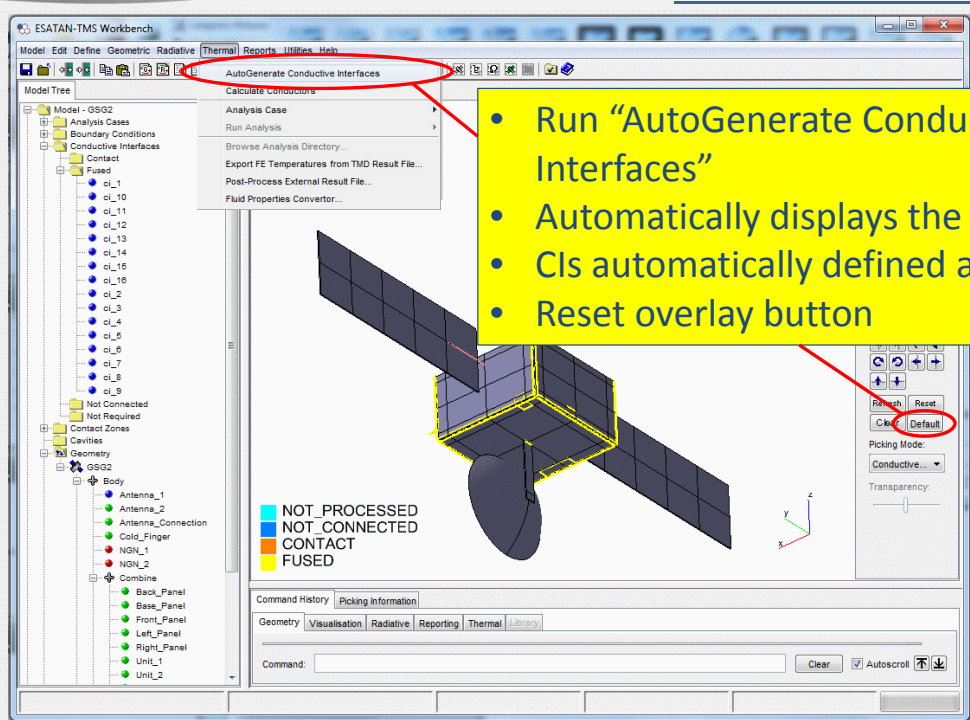
Process Conductive Interfaces

ESATAN-TMS Workbench

Model Edit Define Geometric Radiative Thermal Reports Utilities Help

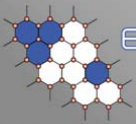
Model Tree

- Model - GSQ2
 - Analysis Cases
 - Boundary Conditions
 - Conductive Interfaces
 - Fused
 - ci_1
 - ci_10
 - ci_11
 - ci_12
 - ci_13
 - ci_14
 - ci_15
 - ci_16
 - ci_2
 - ci_3
 - ci_4
 - ci_5
 - ci_6
 - ci_7
 - ci_8
 - ci_9
 - Not Connected
 - Not Required
 - Contact Zones
 - Geometry
 - GSQ2
 - Body
 - Antenna_1
 - Antenna_2
 - Antenna_Connection
 - Cold_Finger
 - NSN_1
 - NSN_2
 - Combine
 - Back_Panel
 - Base_Panel
 - Front_Panel
 - Left_Panel
 - Right_Panel
 - Unit_1
 - Unit_2



AutoGenerate Conductive Interfaces

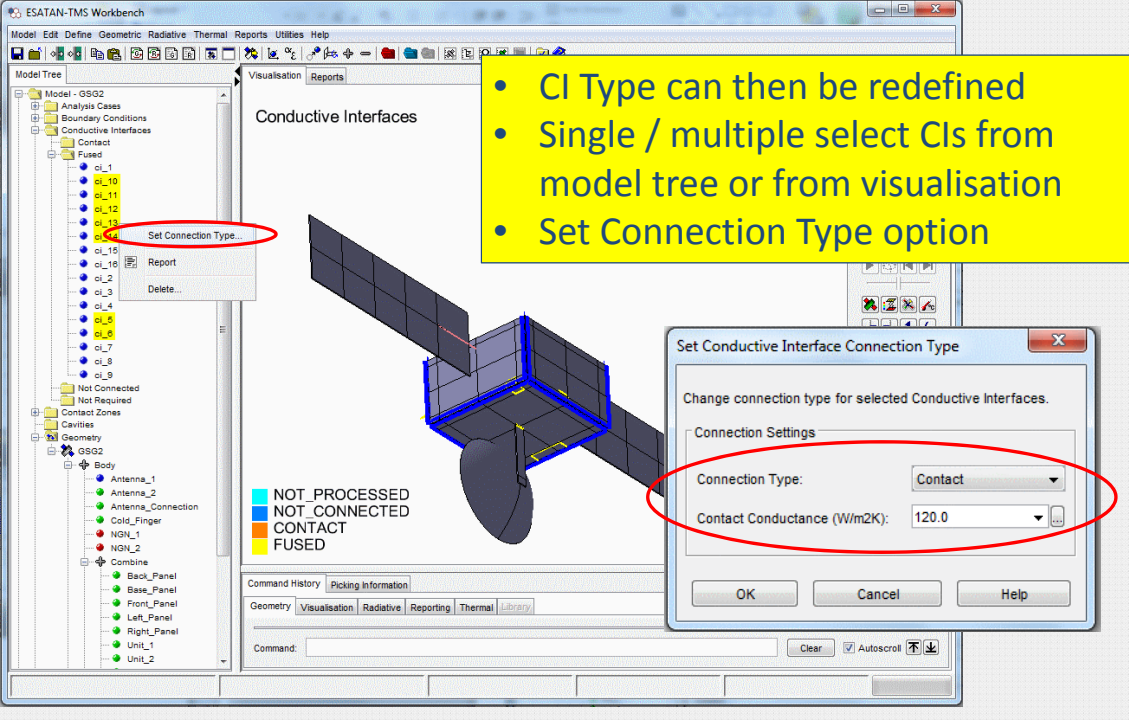
- Run “AutoGenerate Conductive Interfaces”
- Automatically displays the CI overlay
- CIs automatically defined as Fused
- Reset overlay button



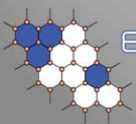
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Improved User Interface

Process Conductive Interfaces



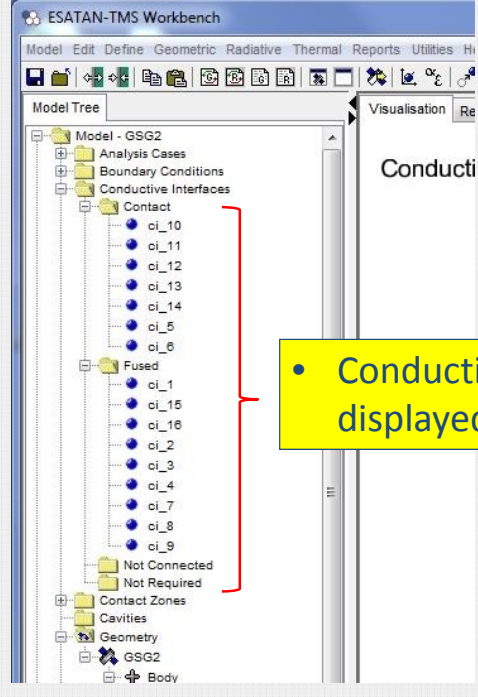
- CI Type can then be redefined
- Single / multiple select CIs from model tree or from visualisation
- Set Connection Type option



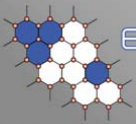
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Improved User Interface

Process Conductive Interfaces



- Conductive Interfaces now displayed by type on model tree

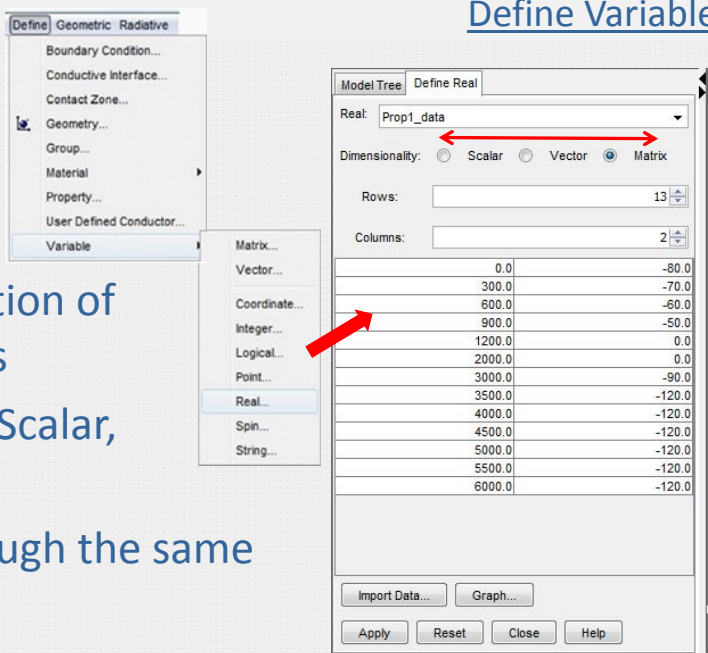


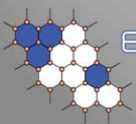
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Improved User Interface

- Interface for definition of basic variable types
- Same interface for Scalar, Vector and Matrix
- Edit definition through the same dialog

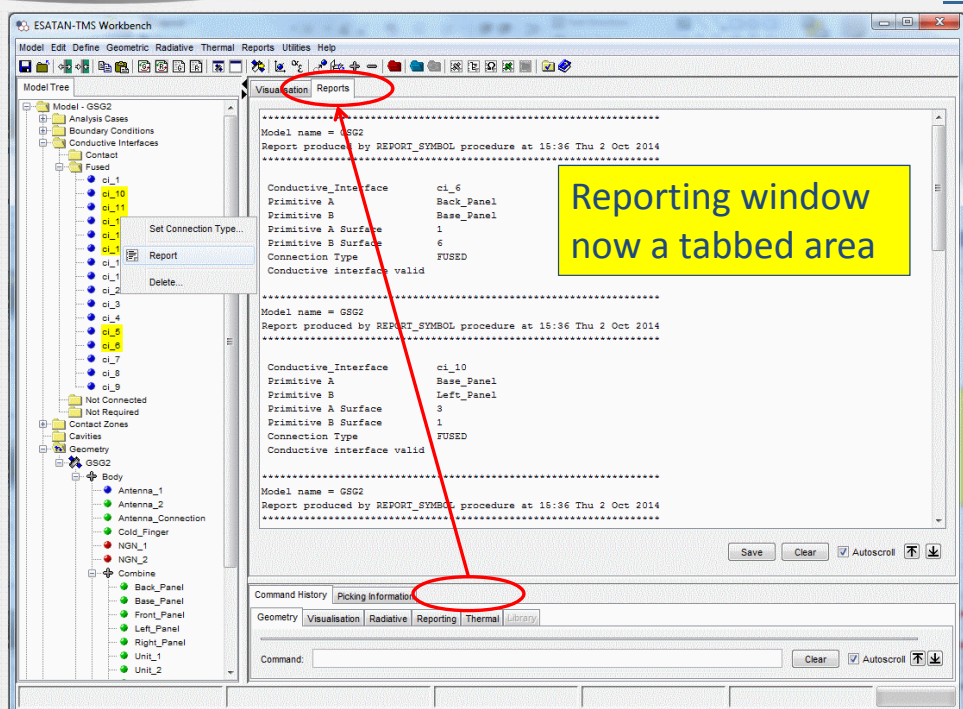
Define Variables



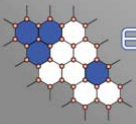


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Improved User Interface



Reporting Tab

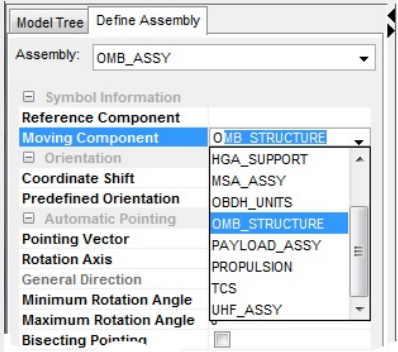


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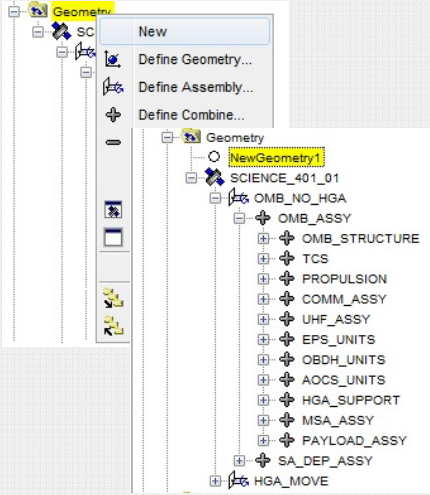
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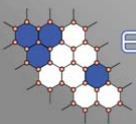
Other Items

- Auto-completion on dialogs



- Geometry New Command

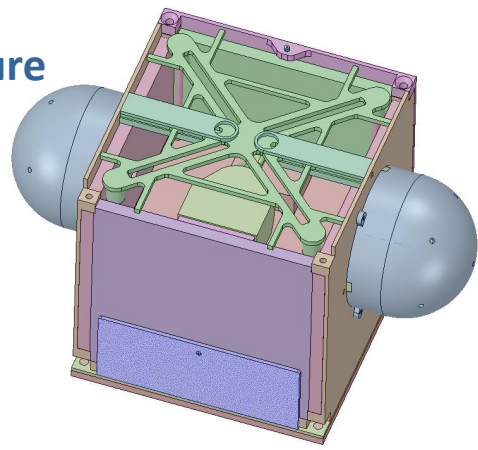


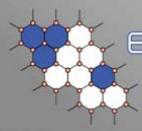


ESATAN-TMS
thermal modelling suite

Contents

- Presentation of ESATAN-TMS development status
 - Model import from CAD
 - Further thermal integration
 - Improved user interface
 - **Modelling time & temperature dependency**
 - Model definition
 - Simplified user input





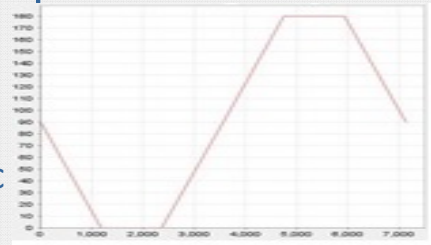
ESATAN-TMS
thermal modelling suite

Time & Temperature Dependency

- Model time or temperature dependent properties in Workbench

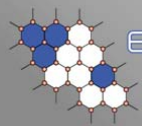
- Define Property

- Time, temperature or time-cyclic
- Plot profile



- Additional support provided in ESATAN-TMS r7

- Time or temperature dependent
 - All components of User-Defined Conductors
 - Conductance of Contact Conductor Interfaces
 - Capacitance of Non-Geometric Thermal Nodes
 - Shell through emissivity & conductance



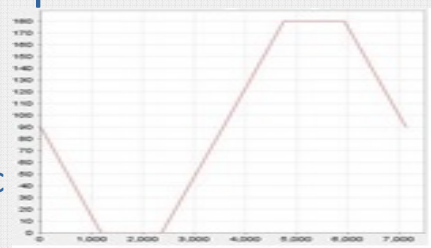
ESATAN-TMS
thermal modelling suite

Time & Temperature Dependency

- Model time or temperature dependent properties in Workbench

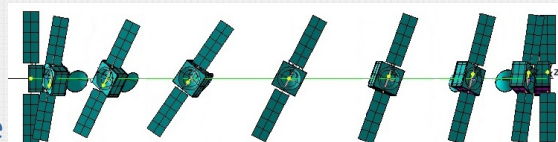
- Define Property

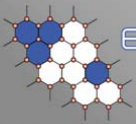
- Time, temperature or time-cyclic
- Plot profile



- Additional support provided in ESATAN-TMS r7

- Time dependent
 - Assembly pointing
 - Environment temperature



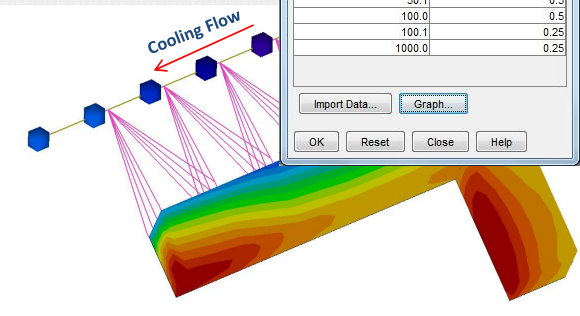


ESATAN-TMS
thermal modelling suite

Time & Temperature Dependency

- User-Defined Conductors
 - Conductance value
 - Components of Calculated option
 - Advective, $\dot{m}$ & C_p
 - Radiative, ε & REF
 - Conductive, k
 - Convective, h

Radiative
Conductive
Advective
Convective

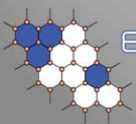


Matrix Chart: airFlow

Property:	airFlow
Dependence:	TIME
Period:	0.0
Rows:	6

0.0	0.25
50.0	0.25
50.1	0.5
100.0	0.5
100.1	0.25
1000.0	0.25

Buttons: Import Data..., Graph..., OK, Reset, Close, Help

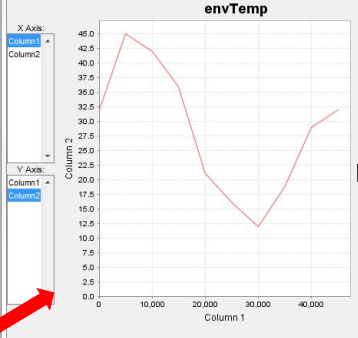


ESATAN-TMS
thermal modelling suite

Time & Temperature Dependency

- Environment temperature boundary condition
 - As for other boundary conditions can be defined time dependent

Matrix Chart: envTemp



Model Tree: Define Analysis Case

Analysis Case: heat

Analysis Case: Template: Analysis

Boundary Conditions: Analysis

Conductors

Output Linear Conductors ☒

Output Radiative Exchange F... ☒

Output REFs ☒

Averaged ☒

Cyclic ☒

REF Multiplying Factor: 1.0

Output Definition

Model Name: GSG_Sat_heat

Dynamic Storage

Environment Node Number: 99999.0

Environment Temperature: airFlow

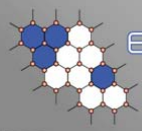
Environment Temperature: A time dependent PROPERTY or REAL parameter specifies the environment temperature used in analysis. If not given, a default of -270. is assumed.

☒ Generate Template File

☒ Generate Analysis File

☒ Run Analysis (Pre-process & Solve)

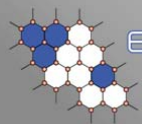
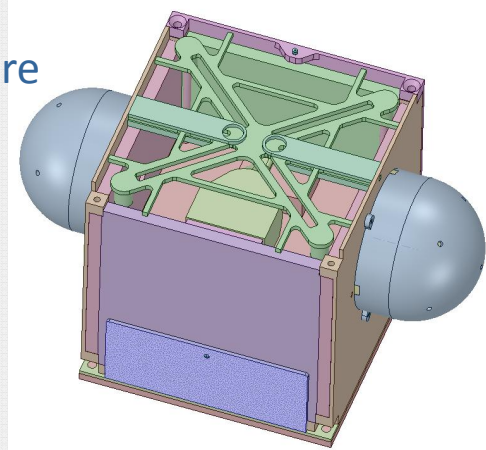
Buttons: Apply, Reset, Close, Help



ESATAN-TMS
thermal modelling suite

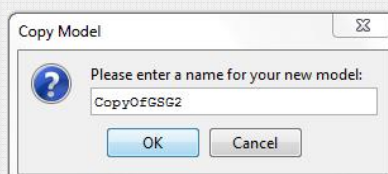
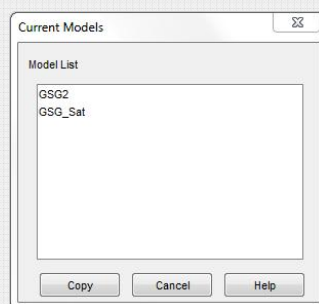
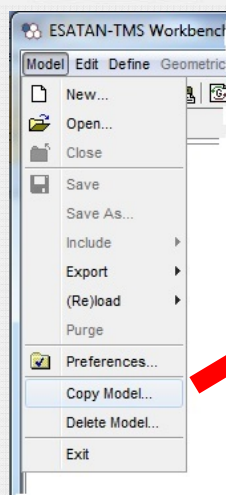
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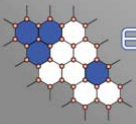


ESATAN-TMS
thermal modelling suite

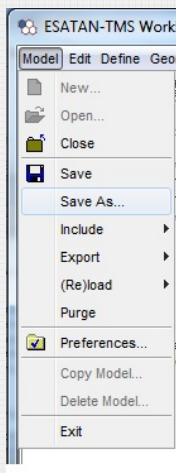
Model Definition



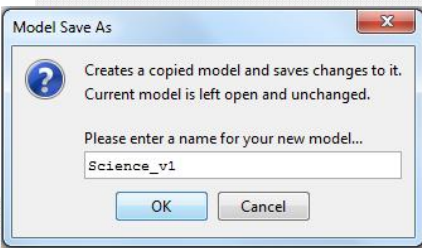
- Improved Copy Model
 - Copy models within the “Model Directory”
 - Now copies **all data**, including result data
 - Updates working directory & other paths



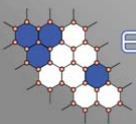
Model Definition



- Model “Save As” option now provided
- Creates a **full** back-up of the model
- Currently open model not changed

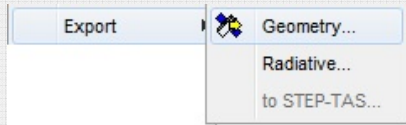


- Version control of the model
- High-priority from the user survey 2013

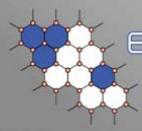


Model Definition

- Export complete model definition
 - **Implementation being finalised**
 - Extended Model Export
 - Export Model option
 - Export Thermal option
 - Extended Model Import
 - (Re)load Model option
 - (Re)load Thermal option



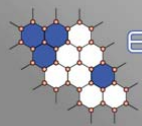
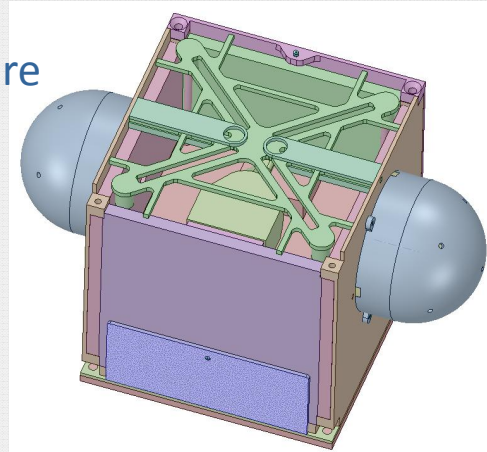




ESATAN-TMS
thermal modelling suite

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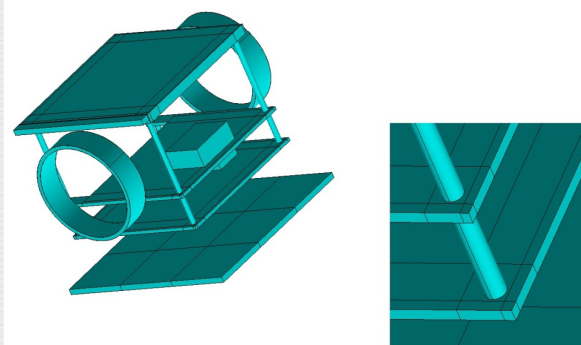


ESATAN-TMS
thermal modelling suite

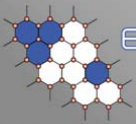
Simplified User Input

- Definition of Real Vectors directly as literal values
 - non-regular mesh

Mesh	
Faces along Direction 1	12.0
Faces along Direction 2	1.0
Ratio in Direction 1	1.0
Ratio in Direction 2	1.0
Mesh Positions in Direction 1	{0.1, 0.3, 0.7}
Mesh Positions in Direction 2	0.2, 0.35, 0.55, 0.9



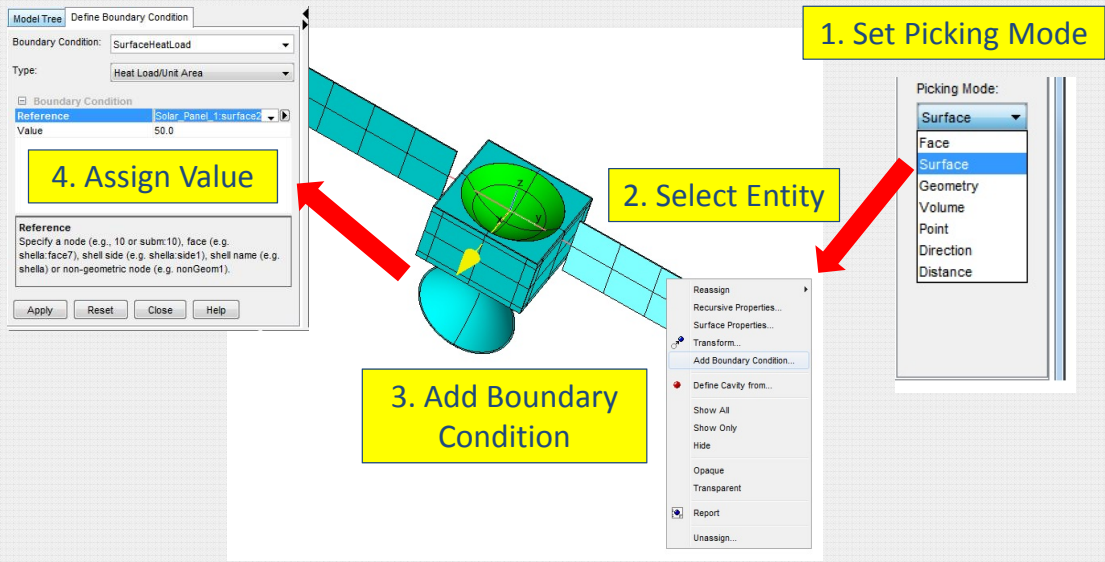
- night-side temperature
- orbit true anomaly
- waveband frequency array

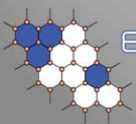


ESATAN-TMS
thermal modelling suite

Simplified User Input

- Assignment of BCs directly onto selected entities in the visualisation

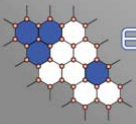




ESATAN-TMS
thermal modelling suite

Conclusion

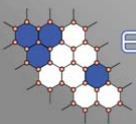
- ESATAN-TMS r7 release at the end of the year
- Continued **major investment** on the product
- Focus on input from **user survey 2013**
 - Improved thermal modelling environment
 - Time & temperature dependency
 - Control of model data
 - Improved performance
 - Simplified input
 - Improved visualisation

**ESATAN-TMS**
thermal modelling suite

Product Support

- New web site, self help, short videos, ...
- Extended Getting Started Guide
- Training courses at ITP
 - Nov 2014 Beginner
 - Jan 2015 Advanced
- On-site training on request
- Thermal consultancy



**ESATAN-TMS**
thermal modelling suite

Product Support

- Maintenance & bug fixing of the product
 - General bug fixing, including STEP-TAS Import/Export
- Obtain feedback on priorities, both immediate and future requirements
 - Web report system
 - Customer visits
 - User survey
- ... and the support team are here!



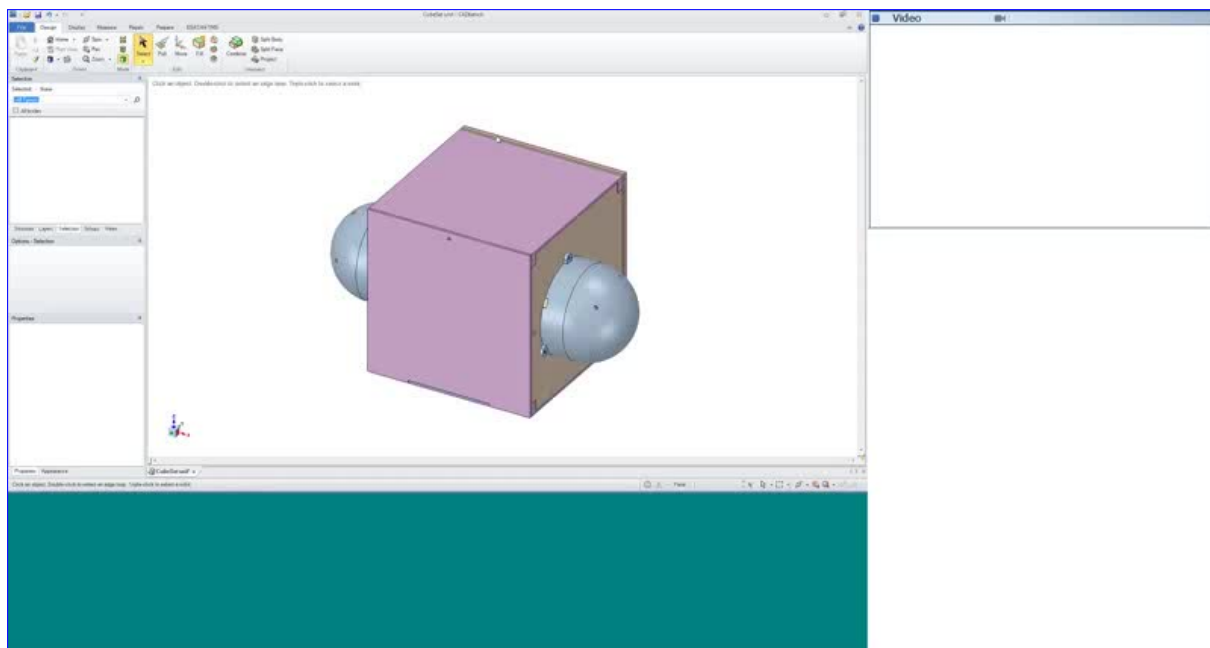
Thank You

Questions following the demonstration



New Functionality (Summary)

- CAD Conversion
 - Shape recognition
 - Merge triangles
 - Option to generate Point Variables
- Thermal Integration
 - New Analysis Case Definition file
 - Control of output of all conductors
 - Automatically calculate conductors
 - Calculate conductors if out of date
- Redesign of dialogs
- Process Conductive Interfaces
- Reporting Tab
- Geometry New command
- Auto-completion on dialogs
- Extension of time & temperature dependency support
- Extended Copy Model
- Model Save As
- Export Complete Model Definition
- Define Vectors directly using literal values



If clicking on the picture above does not run the movie then try opening the file
'movies/Recordvideo2014102113183.html' manually.

