Appendix B

Progress of the CIGAL2 distribution project

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(DOREA, France)

Abstract

To increase the reactivity and performance of thermal analysis, Thales Alenia Space Cannes has decided to integrate step by step its thermal software CORATHERM in the graphical pre and post-processing tool CIGAL2. As it was presented at 2008 ECLS workshop, the objective is to take profit of the powerful, complete and user friendly framework offered by CIGAL2 to extend it to end-to-end thermal analysys process including also computation management.
This year we intend to provide to European thermal users a new release of this integrated tool which will include a full integrated 3D conductive chain, a thermal model reduction tool (Thales Alenia Space Torino & Toulouse) and an orbitography module. Besides this the CIGAL2 new generation application combines a powerful modelling and meshing tool with the main CORATHERM modules to perform thermal analysis on a future satellite or payload.
This paper presents also the improvement brought to Coratherm architecture in order to make it more outstanding and to increase its performances and reactivity. Recently CIGAL2 has been chosen to be the CAD modelling tool for draft designing of satellite thermal control during invitation to tender phases in Thales Alenia Space Cannes.
Finally, this tool will be also available soon for other purpose than thermal such as ESD analysis, CIGAL2 integrating SPARCS simulation complete process and for electronics thermal control design.

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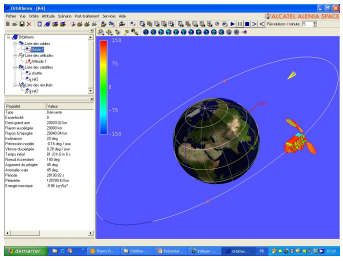
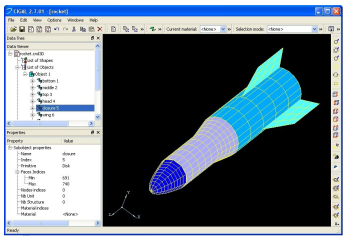
Progress in CIGAL2 distribution project





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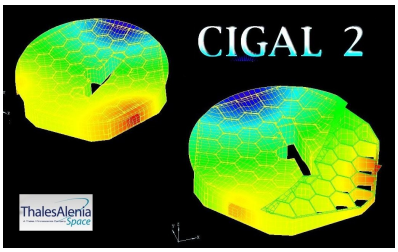
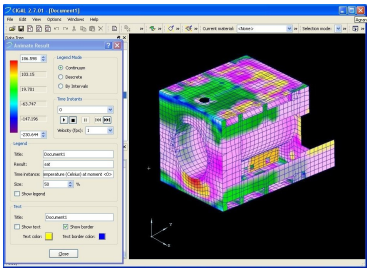
F. BRUNETTI (DOREA)





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Summary

- Policy an context around CIGAL2 distribution project
- Progress in CIGAL2 developments in 2009
  - Integration of a Radiative module
  - Integration of 2D & 3D Conductive modules
- CIGAL2 project in 2010
  - Integration of the CORATHERM solver (RPT)
  - Integration of the orbitography module
  - Improvement of the 3D meshing capabilities
- New applications for CIGAL2

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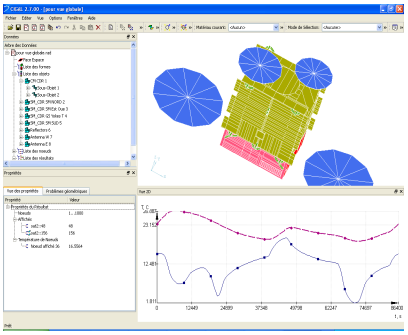
Current and Future Policy

- TAS thermal s/w strategy is focused on :
  - Maintain & improve
    - ➔ Performance, Reliability, Flexibility, Reactivity of used tools
  - Develop CORATHERM and data standard exchange (STEP-TAS)
  - Opening of CORATHERM
    - ➔ **2008** : Distribution of our Pre and Post processing tool CIGAL2
      - Supply of CIGAL2 according to software licence agreement and secured patch
    - ➔ **2009**: Distribution of CIGAL2 new release including radiative and conductive calculation
      - http://download.dorea.eu/user/cigal2/
  - This tool, fully funded by Thales Alenia Space, will not be commercialised but freely distributed with a maintenance funding :
    - ➔ by TAS for corrective maintenance
    - ➔ by customer for specific needs (evolution maintenance)
    - ➔ by agencies for basic needs (evolution maintenance)

    Developments will be managed by Thales Alenia Space.
  - Contact : thierry.basset@thalesaleniaspace.com

Pre and Post processing tool CIGAL2

- Context
  - Tool developed initially by Open Cascade and then by DOREA since 2007
  - Tool owned by Thales Alenia Space
- Brief functional overview
  - Pre-processing part
    - → Import of CAD files
    - → Building of radiative GMM with materials and nodal breakdown
    - → Building of 2D & 3D conductive GMM with materials and nodal breakdown
    - → Checking models
  - Post processing part
    - → 2D curve plotting
    - → 3D cartography of results with animation for transient
  - *And now* some integrated computation modules



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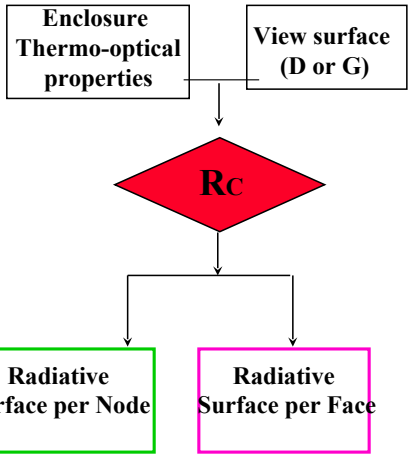
Integration in CIGAL2 of Radiative Exchange Calculation

- From view surfaces : calculation of radiative couplings taking into account diffuse multi-reflections and transmissions
  - Advantage : Change easily material characteristics for adjusting radiative exchanges
  - Method valid if uniform flux per node to take into account reflection with more accuracy



- Radiative Surfaces Calculation in a cavity based on matrix method

$$R_{ij}^{-1} = SV_{ij}^{-1} - \begin{vmatrix} \frac{1-\varepsilon}{\varepsilon S} & 0 & \dots \\ 0 & \dots & 0 \\ \dots & 0 & \frac{1-\varepsilon}{\varepsilon S} \end{vmatrix}$$

  - Method well adapted in the case of little models
    - ➔Small Matrix => low calculation time
  - Method well adapted in the case of surfaces with a high reflectivity (material with low emissivity)
    - ➔In this case iterative method is less efficient (needs a lot of iterations)

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Integration in CIGAL2 of Conductive Exchange Calculation

Presentation of RC conductive module (1/2)

- On the basis of the 2D or 3D conductive GMM (Pre-pro)
- Automated computation of elementary conductive couplings
  - FDM (2D) or FEM (3D) detailed conductive model
- Reduction of the detailed model and generation of the equivalent TLP model
  - Condensation of the detailed model to keep only couplings between **user defined "macroscopic" nodes**
  - **Take count of radiative aspects** in the reduction process
  - **Outputs : *Equivalent* conductive couplings compliant with other TLP solvers (ESATAN)**
- Possibility to recalculate temperature on original detailed model from the reduced thermal model
  - Very useful to transfer detailed temperature cartography to mechanical engineer for thermo-elastic analysis

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Integration in CIGAL2 of Conductive Exchange Calculation

Presentation of RC conductive module (2/2)

- Other capabilities
  - Easy connection between several conductive models in contact through interface nodes (no need of a concurrent mesh)
  - Definition of super-nodes by gathering various thermal nodes (for example when small gradients are firstly observed) : “averaged nodes”
  - Elimination of thermal nodes non required in the final model : “suppressed nodes”
  - Temperature or power zoom on some zone of the model : “partial or recalculated nodes”
  - Automated computation of nodal thermal capacitance on shell models
  - ***Automatic redistribution of nodal thermal capacitance on bulk type 3D models***

Soon

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Integration in CIGAL2 of the Conductive Module : Visualisation

Video Chaine conductive intégrée :
F. Brunetti

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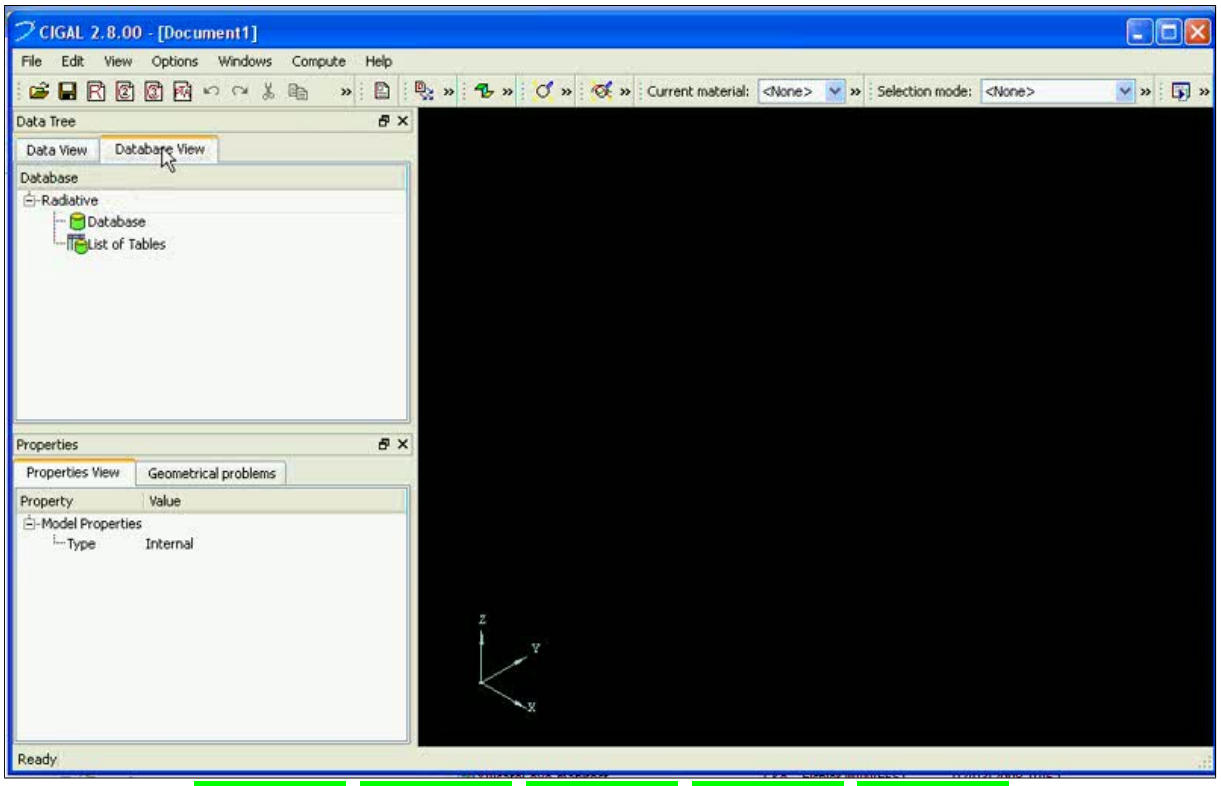

Slow Normal Fast Play/Pause Stop

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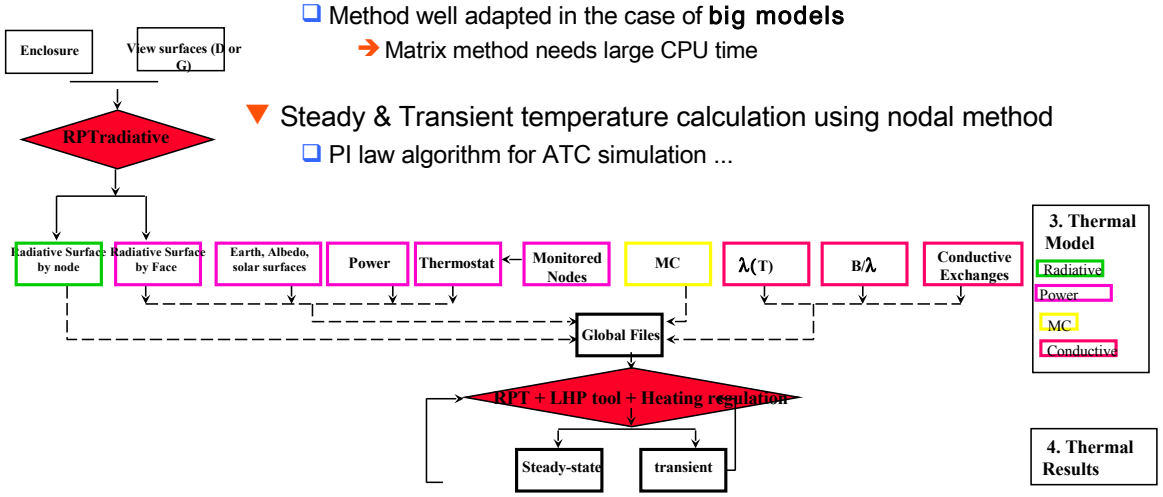
Integration of Thermal solver (RPT) in CIGAL2

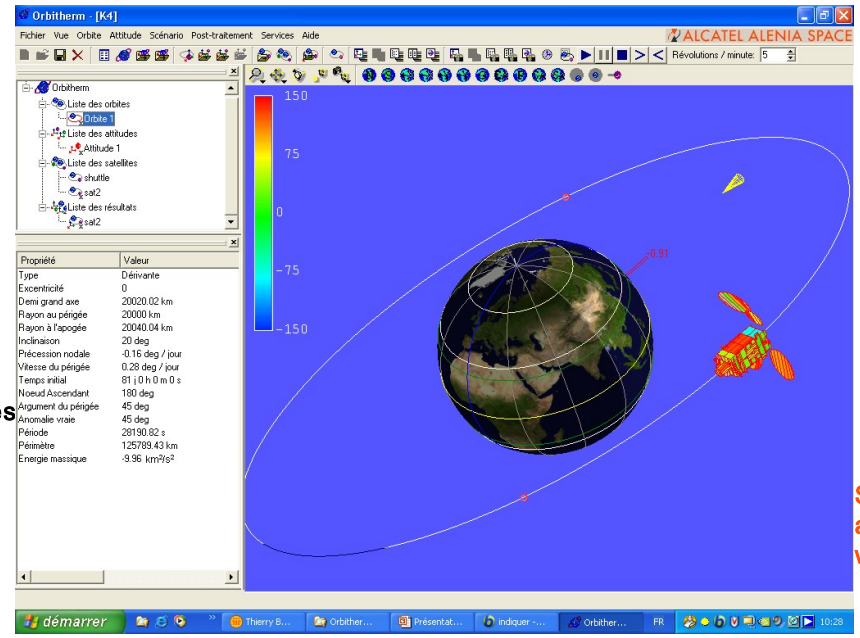
- Radiative surfaces Calculation in a cavity by **iterative method**. The aim is to calculate the absorbed power by nodes
  - Iterative algorithms well adapted in the case of surfaces with **high absorptivity/emissivity**
    - ➔ generate a low number of iterations
  - Method well adapted in the case of **big models**
    - ➔ Matrix method needs large CPU time
- Steady & Transient temperature calculation using nodal method
  - PI law algorithm for ATC simulation ...



Integration of Orbitography module

Model Data Tree

Properties Editing



3D interactive window (build, check and display)

Soon fully available within CIGAL 2

Integration of a new 3D meshing in CIGAL2

- Objective : Enhance reactivity and quality of 3D conductive modelling
- Main requirements
  - Improvement of the current module dedicated to 3D conductive modeling
    - → More powerful CAD link
      - Direct shell mesh generation from CAD definition inputs
    - → More powerful 3D shell and volumic mesher
      - New poly-line primitive
      - Replacement of NETGEN by GMSH
      - Mesh and prepare nodal breakdown
      - …
    - → Automated assistance to user for matching mesh between neighbouring surfaces
    - → …
  - Preparing opening of CIGAL2 to other domains (ESD analysis)
    - → Enlarge CAD import capability
      - Import and manage solids for example

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Project : CIGAL2 for ESD analysis

Context

- SPARCS is Thales Alenia Space simulation tool for GEO satellite charging simulation based on plasma-spacecraft interaction modelling

Objective

- Today SPARCS is interfaced with COTS s/w for pre and post processing and this causes some industrial problems
  - ➔Reducing cost by using license free s/w
  - ➔Simplify handling and external distribution of SPARCS
  - ➔Add some new pre-post capabilities (e.g more assisted retouch of CAD geometry, 3D transient animation of results, …)
- Need for an integrated end-to-end s/w chain for ESD analysis

2009/2010 Project

- Development of an integrated S/C charging simulation chain in CIGAL2
- Collaboration TAS-DOREA
- A first step toward a multidisciplinary tool (Thermal / Space Environment)

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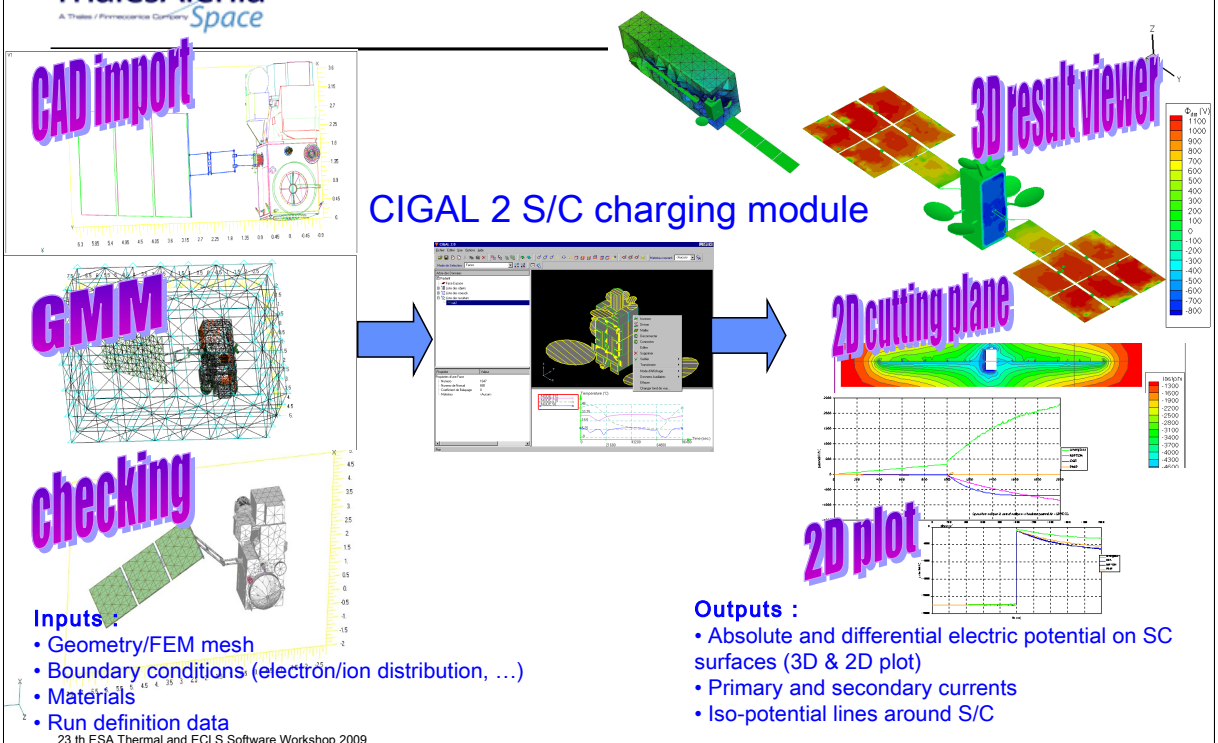
Project : CIGAL2 for ESD analysis



Inputs :
- Geometry/FEM mesh
- Boundary conditions (electron/ion distribution, …)
- Materials
- Run definition data

Outputs :
- Absolute and differential electric potential on SC surfaces (3D & 2D plot)
- Primary and secondary currents
- Iso-potential lines around S/C

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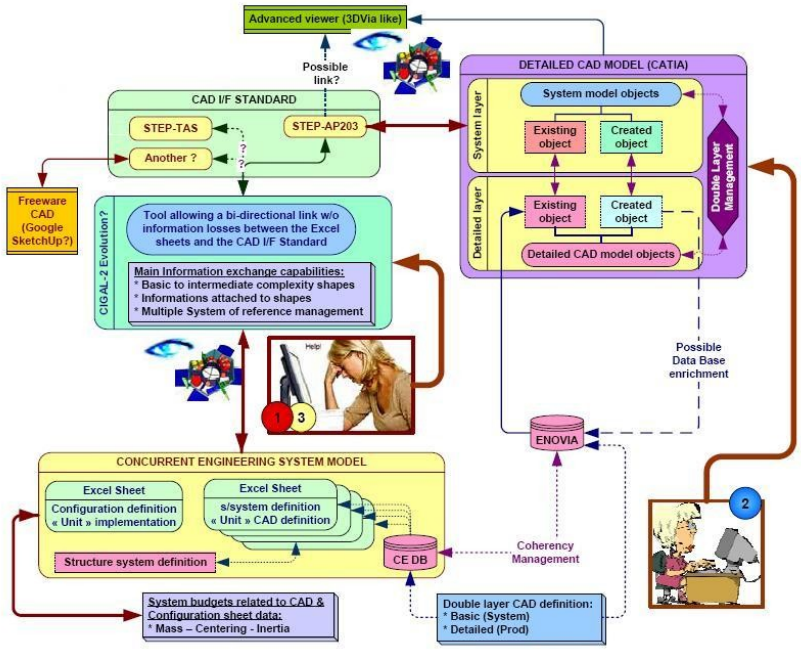
Project : CIGAL2 like interfaces between CDE and CAD application



Other applications in view

- Outside TAS Cannes scope …
  - Several presentations of the project in THALES group aroused interest for various thermal activities
    - ➔TAS-Toulouse for antenna studies
    - ➔TAS-Torino for infrastructure & instrument
    - ➔Thales Group for electronic cards & units
    - ➔Thales Group for electron emitter device
  - Presentation and proposal to test CIGAL 2 to the european thermal s/w community
    - ➔Second distribution at 23th ECLS Workshop
    - ➔***Some feedback from test of 2008 release ?***