

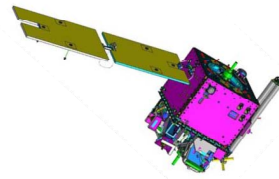
## Appendix O

### GAETAN 5: A complete environment for thermal analysis

Hélène Pasquier  
(CNES, France)



# GAETAN V5 :



## A Global Analysis Environment for Thermal Analysis Network



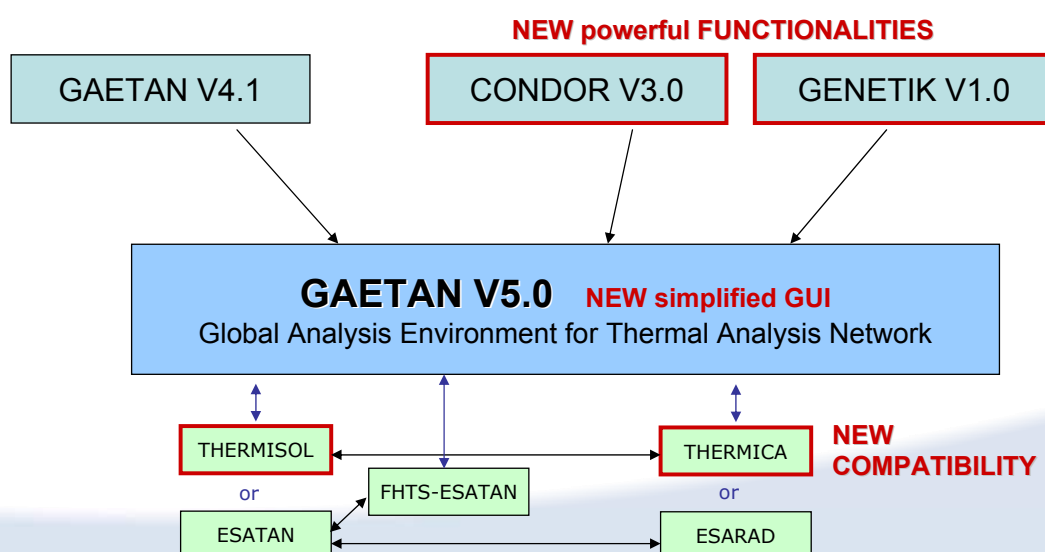
PASQUIER Hélène, *Thermal Engineer, CNES*

IMHOF Marie, *Computer Scientist, SILOGIC*



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## Presentation of GAETAN V5



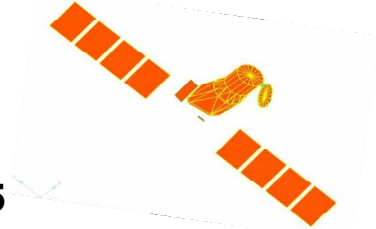
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## Presentation of GAETAN V5

### - Agenda -

- **Main Functionalities of GAETAN**
- **New Functionalities of GAETAN V5**
  - CONDOR : *A simplified search for external orbital conditions*
  - GENETIK : *A genetic algorithms approach*
- **The New Software GUI**



## Main Functionalities of GAETAN

- Thermal model configuration management
- **Thermal studies management**  
 (Analysis study replay modes after model upgrade, for sensitivity studies, a.s.o.)
- Automatic thermal model import / export functionalities
- Practical use of names for calculation cases, heat load cases, groups of nodes, heat balance, calculation times, a.s.o.
- **Complementary entities helpful for thermal study management**  
 (i.e. : groups of nodes, condensed nodes, boundary fluxes, instantaneous thermal slopes, a.s.o.)



## **Main Functionalities of GAETAN**

- **Save of any thermal data** (during a thermal solver run) to be used for several post-processing analyses
- Calculation of average, extrema (min-max) and differences for groups of nodes
- **Heat balance analysis** : detailed exchanged heat flows diagnostic and extrema
- Heat balance analysis extended to single & two phase calculations (compatibility with FHTS) + dedicated mass flow analysis



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## **Main Functionalities of GAETAN**

- **Radiator / Heat sink analysis** (Sink temperature, heat rejection, heat power on simulated heat sink during thermal test ...)  
Useful for thermal balance test engineering
- Use of specific \$ELEMENTS in addition to ESATAN or THERMICA (P-PI regulation, pre-meshed elements (rods, plates, triangles), Peltier Thermo elements (single & multi stages), convergence verification tool, calculation time step management tool, a.s.o.)
- **Automatic results comparison**
  - With specification, with test results, between several calculation cases
  - Between nodes, groups of nodes
  - Using mapping table



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## Main Functionalities of GAETAN

- Save of external fluxes or temperatures to initialize another calculation case
- Thermal coupling cases analyses
- Thermal sensitivity analyses
- Help for model reduction (energetic approach)



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## New Functionalities of GAETAN V5

### - CONDOR : A simplified search for external orbital conditions -

- This module is used to evaluate external orbital conditions for :
  - ♦ simple geometry : single & double plate, sphere, cylinder, cube,
  - ♦ classical orbit : geostationary, polar, heliosynchronous or elliptical,
  - ♦ attitude conditions : Sun pointing, Earth pointing, velocity pointing a.s.o
- But is also used for evaluation of external orbital conditions of any complex geometry (working together with THERMICA or ESARAD software) in any orbital / attitude condition
- Compatible with data inputs coming from other disciplines : Attitude quaternion, tabular data for specific attitude control functions coming from AOCS sub-system ...



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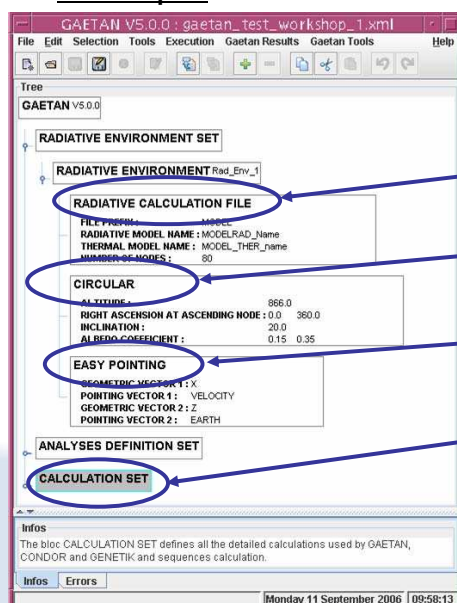
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## New Functionalities of GAETAN V5 - GAETAN / CONDOR coupled analysis -

- Thermal software tools used at CNES
  - GAETAN + CONDOR + ESATAN – ESARAD since 2002
  - GAETAN + CONDOR + THERMICA (& THERMISOL) since 2005
- GAETAN V5 launches both radiative & thermal calculations and compares any type of user requested results ( $T^\circ$ ,  $DT$ ,  $dT/dt$ ,  $DT/(t_1-t_2)$ , min/max, heating power, external fluxes, absorbed fluxes, boundary fluxes, a.s.o...) allowing an automatic, efficient and precise search for thermal dimensioning cases.
  - Research during a year or for an orbit
  - Calculation at any user chosen step

## New Functionalities of GAETAN V5 - CONDOR -

Example : SCARAB Electronic module (EM)



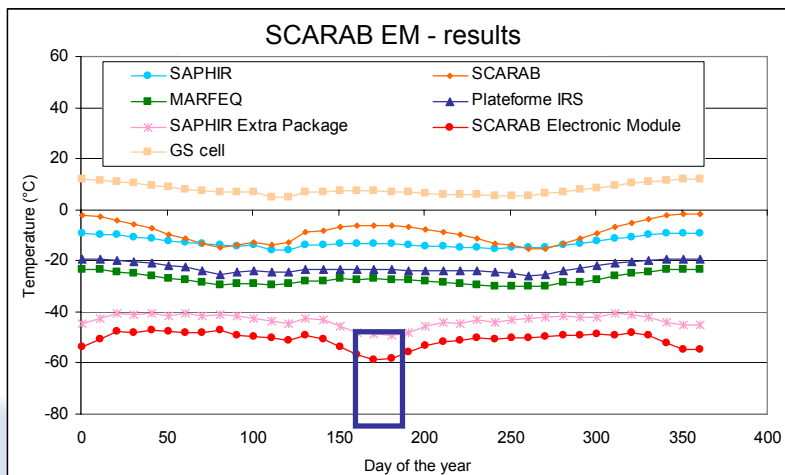
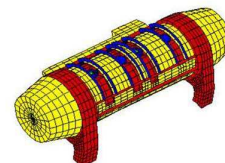
CONDOR's file contains :

- Geometry definition
- Orbit definition
- Attitude definition
- Work definition



## New Functionalities of GAETAN V5 - CONDOR -

Example : SCARAB Electronic module (EM)



**First calculation**  
between day 1  
and day 365



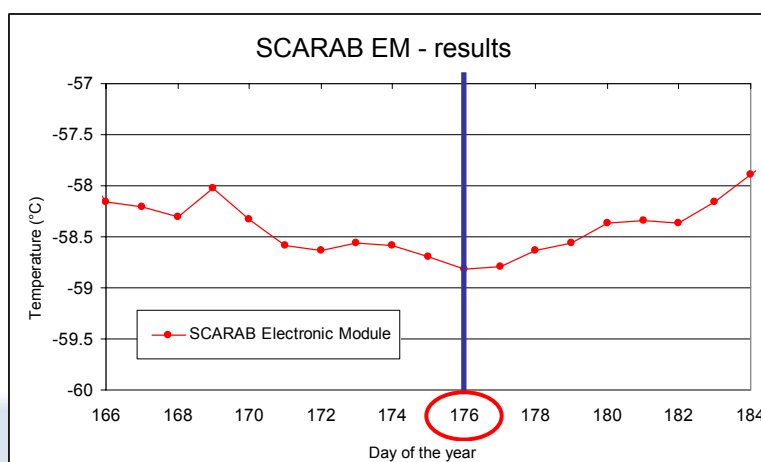
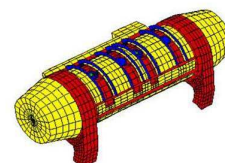
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## New Functionalities of GAETAN V5 - CONDOR -

Example : SCARAB Electronic module (EM)



**First calculation**  
between day 1  
and day 365

**2<sup>nd</sup> calculation**  
between day 165  
and day 185



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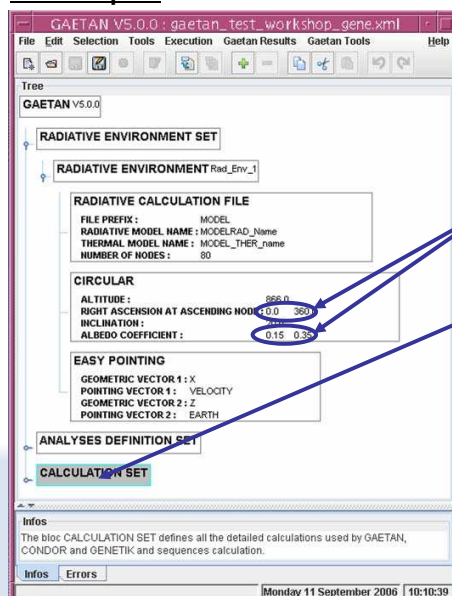


## New Functionalities of GAETAN V5 - GENETIK -

- Module using of GENETIC Algorithms to optimise search for thermal dimensioning cases
- Possibilities to define ranges of variation for various parameters
- Evaluation of these parameters and determination of the set which gives the worth case (in term of  $T^\circ$ ,  $DT$ ,  $dT/dt$ ,  $DT/(t_1-t_2)$ , min/max, heating power, any external flux, absorbed flux or flux combination, a.s.o.)

## Main Functionalities of GAETAN V5 - GENETIK -

Example : SCARAB Electronic module (EM)



GENETIK's file contains

- All CONDOR's file lines
- The range of value of the parameters to optimise
- Specific parameter entered in the Calculation Set Bloc



## Main Functionalities of GAETAN V5 - GENETIK -

Example : SCARAB Electronic module (EM)

Text Editor - bestx.c

File Edit Format Options

Número de ligne dans le fichier config.clv :

	Valeur :
sol =	
27	191.63
31	0.34
57	137
sol_tot =	
27	179.08
31	0.34
57	172

GENETIK algorithm provides the best set of parameter, for SCARAB EM

- A right ascension of the ascending node of 179,08 °
- An albedo coefficient of 0.34
- The 172<sup>nd</sup> day of the year



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## GAETAN V5 : The New Software GUI

GAETAN V5.0.0 : QBLOCD.xml

File Edit Selection Tools Execution Gaetan Results Gaetan Tools Help

Tree

- GAETAN V5.0.0
  - GENERAL OPTIONS
    - ENERGY FORMAT : 0.000
  - THERMAL MODEL QBLOCD
  - ANALYSES DEFINITION SET
    - CONDENSED NODES SET
      - CN noeud condense 1
        - List of nodes : MODEL :10-20,30
        - Calculation option : C
      - CN noeud condense 2
        - List of nodes : 90
        - Calculation option : A
        - Type : B

Infos

The bloc CONDENSED NODE defines a condensed node.

Infos Errors

Tuesday 05 September 2006 14:52:11

The aim of the new GUI is to make the software easier to use.

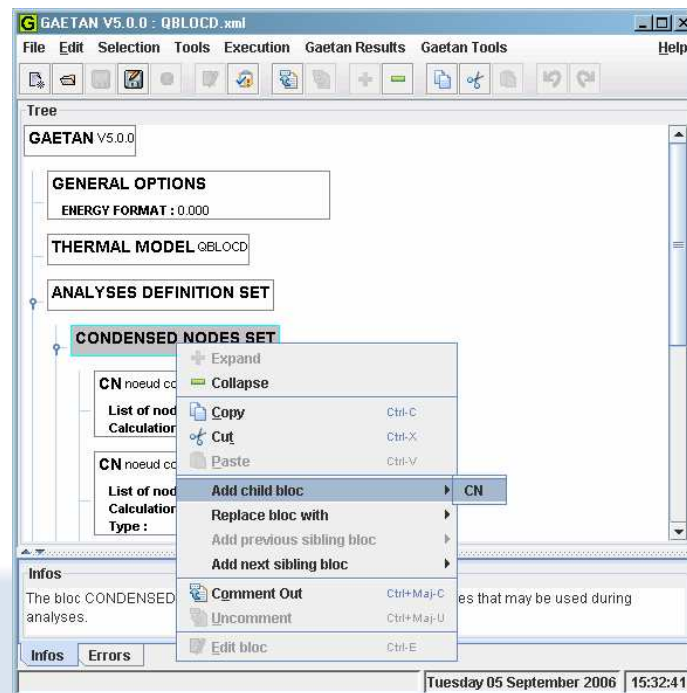


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## GAETAN V5 : The New Software GUI



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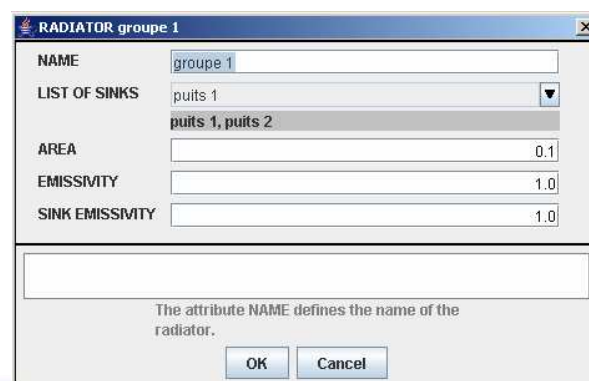


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## GAETAN V5 : The New Software GUI

- The user defines input data in the appropriate popup.



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## ***GAETAN V5 in the European context***

- CNES policy : to place all validated CNES thermal tools at “ESA member states” disposal (as proposed at the ESA Steering Board “Thermal & Space Environment Software Tools”)
- GAETAN is compatible with the two European COST thermal tools :
  - ◆ THERMICA / THERMISOL
  - ◆ ESATAN / FHTS / ESARAD
- The new GUI, user manual and licence contracts will be translated in English
- Product available for any ESA member states through a CNES licence and a maintenance contract with CNES developer SILOGIC



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## ***GAETAN V5 in the European context***

**A thermal environment tool available mid of 2007**

after a first period of operational use / verification at CNES



« We hope so ... »



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## GAETAN V5

**A Global Analysis Environment for Thermal Analysis  
Network**

***Main Functionalities***



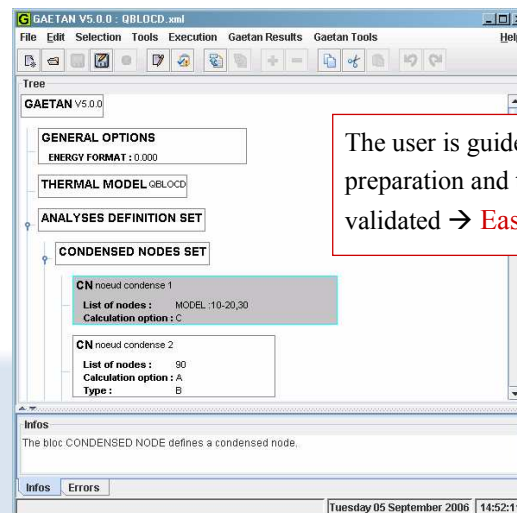
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GAETAN is a CNES software developed by SILOGIC. This environment, working together with either THERMICA / THERMISOL (EADS ASTRIUM Fr. products), or ESATAN / ESARAD / FHTS (ALSTOM UK products) thermal software is dedicated to space thermal control engineering and covers most of current thermal users pre and post processing needs.

This document lists the main functionalities provided by GAETAN through a new friendly user interface.



The user is guided during the calculation preparation and the file is automatically validated → **Easier use of the tool**



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## GAETAN V5 - Main Functionalities



### PRE-PROCESSING OPTIONS :

#### Definition of load cases and calculation cases :

The user defines

- ♦ several load cases (external fluxes, boundary conditions, thermal dissipations) representative of all physical thermal loads applied to the model,
- ♦ Several calculation cases, associated with these different load cases.

#### Group of nodes - Condensed nodes - Family nodes :

User may define :

- ♦ Groups of nodes for heat balance analysis, to focus on important thermal zones,
- ♦ Condensed nodes (calculation based on arithmetic or weighted average ...), to reduce results listing (homogeneous zones condensed in one node).
- ♦ Families for redundant subsets.



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## GAETAN V5 - Main Functionalities



### A study level :

Some top level management functions (used in a so called "Study level") allows users to completely or partially replay a previous thermal study and to manage results inter comparison.

### Some user friendly model management capabilities :

- ♦ User defined names (project names for example) are used for calculation cases, load cases, group of nodes, CPU characteristics instants...
- ♦ Output data units and units precision can also be modified by users.

### Coupling cases :

For a given calculation set, the user can define a link between a name and a value (external fluxes or conductors). Then these values are called by their associative names.

### Sensitivity cases :

It allows to make some various calculations and to compare the sensitivity cases with the nominal one.



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## GAETAN V5 - Main Functionalities



### Archives :

The user can archive some ESATAN/THERMISOL results (for later run initialization ...) and / or some GAETAN results (for later post processing...)

## **OPTIONS FOR THERMAL SOLVER RUN**

### Automatic Options :

Calculation results are automatically saved (binary format) : new post processing can be done without starting a new run again.

### Use of \$Elements :

PID or TOR regulations, meshed elements (Bar, plaque, square), peltier elements, convergence verification tool, calculation step management tool... are provided in GAETAN.

The convergence is automatically verified for a stabilized cycling calculation (convergence criterion defined by user).



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## GAETAN V5 - Main Functionalities



### POST-PROCESSING OPTIONS :

#### Automatic Editions :

GAETAN automatically provides numerous information such as :

- ♦ Model statistics (number of nodes ...),
- ♦ Initial conditions,
- ♦ Temperatures at the end of each steady state run & at the beginning and the end of transient run,
- ♦ Tmin, Tmax, Tmean for each node on the transient run,
- ♦ Global heat balance for each steady state and transient run.

#### Heat Balances :

The user can obtain global or detailed heat balance for nodes or groups of nodes. Heat balance and mass flow analysis are also possible for fluidic nodes.



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## GAETAN V5 - Main Functionalities



#### Radiator / sink Study :

This function is very useful for thermal balance test engineering. The user can prepare thermal tests by a radiator / sink study : well configured heat sinks are determined to simulate external thermal conditions during tests (calculation of sink temperature, heat rejection, heat power on simulated heat sink).

#### Spatial Temperature Difference :

Spatial temperature difference may be provided thanks to the use of nodes families : temperature difference between two nodes, two nodes' families, or into the nodes' family itself (minimum and maximum temperature in a given family)

#### Corresponding Mapping Table :

This option allows to compare different sets of results (two different models results, or model and tests results).



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## GAETAN V5 - Main Functionalities



### **MIXED PRE and POST PROCESSING OPTIONS :**

#### Search for thermal Dimensioning cases (Condor & Genetik Modules) :

A thermal engineer can easily search for thermal dimensioning cases for :

- ♦ Simple geometries (plate, double-plate, cylinder, sphere, cube) or any complex geometries (together with either THERMICA, either ESARAD)
- ♦ classical orbit : geostationary, polar, heliosynchronous or elliptical
- ♦ current attitude conditions : Sun pointing, Earth pointing, velocity pointing a.s.o
- ♦ any complex orbit / attitude conditions through tabular data or data inputs coming from attitude control sub-system (i.e. attitude quaternion)

and on any user defined thermal entity, i.e. flux combination, absorbed flux, Tmin, Tmax or Tmean, Temperature gradient, Temperature excursion, a.s.o.

A more efficient search / less consuming CPU time less is also possible taking benefit from a genetic algorithm method.



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## GAETAN V5 - Main Functionalities



### Comparisons :

Several comparisons are possible :

- ♦ between calculation and test results,
- ♦ between calculation results and specifications (defined by the user),
- ♦ between several calculation results (in term of temperature, heat power, temperature gradient, temperature excursion, a.s.o.)

### Help for Model Reduction (Energetic approach) :

A dedicated module helps users to take benefit from the energy management capability of GAETAN in order to manage more efficiently (and quickly) a model reduction.

GAETAN then allows comparisons between results from the reduced thermal model and detailed thermal models.



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## GAETAN V5 - Main Functionalities



### OTHER OPTIONS :

#### GUI :

To simplify his work, the user is guided by the GUI, which :

- ♦ Allows to define easily a thermal study (thus defining GAETAN input file: every information from the pre to the post processing including the run and advanced functionalities can be found in a unique file), by presenting every GAETAN functionalities,
- ♦ Ensures the study by checking the syntax of the GUI generated input file, to be immediately able to correct a possible mistake.

#### Help functions :

Moreover, examples of complete studies are provided through the GUI.

#### Import / Export :

Thermal models can be imported or exported from GAETAN (for data transfer).



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