Appendix P

TCDT: An environment for preliminary thermal analysis and design

Matteo Gorlani
Andrea Tosetto
(Blue Group, Italy)

Thermal Concept Design Tool

Matteo Gorlani, Andrea Tosetto
Blue Engineering, Torino, Italy
Luca Tentoni, Valter Perotto
Alcatel Alenia Space, Torino, Italy
Harrie Rooijackers
European Space Agency, Noordwijk, The Netherlands

20th European Thermal and ECLS Software Workshop
4-5 October 2006, ESA/ESTEC
Sheet 1

Overview

- **Background**
- **TCDT System**
- **TCDT Databases**
- **Thermal Calculator**
  - Linear Conductors Definition
- **Thermal Simulation Manager**
  - Design Process with TCDT
- **Conclusions**

20th European Thermal and ECLS Software Workshop
4-5 October 2006, ESA/ESTEC
Sheet 2

Background (1/2)

FEASIBILITY AND PRELIMINARY PHASES

REQUIREMENTS FOR TCS DEVELOPMENT:

- Experience of Thermal Control System (TCS) development
- Attitude towards a cooperative effort within the system
- Deep knowledge of specific software tools

HIGH PRIORITIES:

- Investigation of design options
- Optimisation of time schedule
- Interaction with other disciplines
- Conceptual activities rather than simulation activities

Background (2/2)

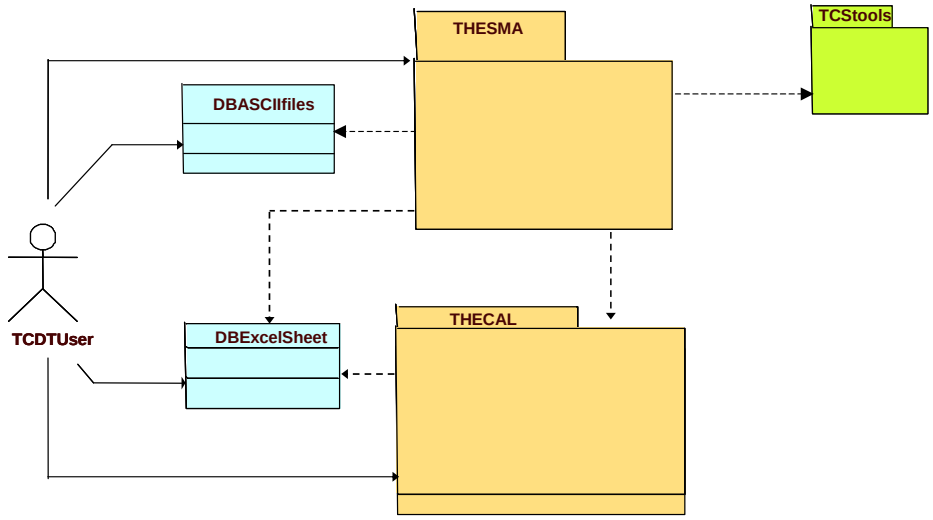
ESA AWARDED A CONTRACT TO *BLUE ENGINEERING* AND *ALCATEL ALENIA SPACE TORINO* WITH THE OBJECTIVE TO IMPROVE THIS SCENARIO WITH A NEW TOOL ABLE TO:

- Provide a flexible and easy environment to investigate a large number of different configurations and TCS options
- Increase the integration between the TCS discipline and other disciplines, in order to speed-up the S/C optimisation
- Support a change of method in the S/C and in particular TCS design, moving toward a design oriented approach
- Exploit the functionalities of ESATAN, ESARAD, ThermXL, ARTIFIS and TOPIC by allowing the user to use them at an higher level

Activity

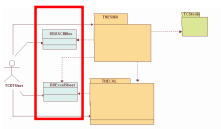
- started in April 2004
- TCDT ver. 1.1 delivered th 4th of September 2006

TCDT System



TCDTdatabases **TCDTaddin** **TCStools**

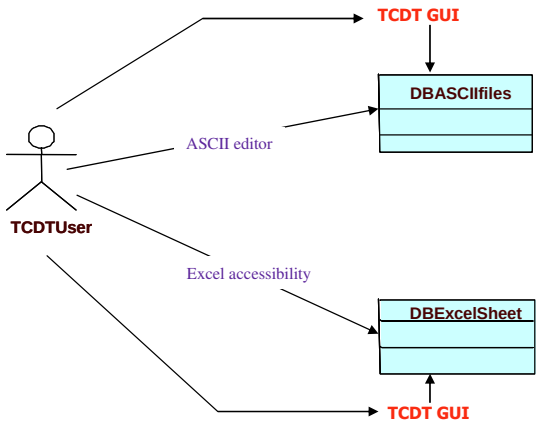
TCDT Databases



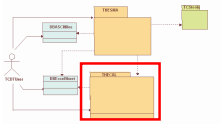
Two types of databases:

- An Excel workbook (DbSheet): geometry, thermal characteristics, analyses and results
- An ASCII file (DBASCIIFile): TCDT configuration and planets database.

User Access to Databases

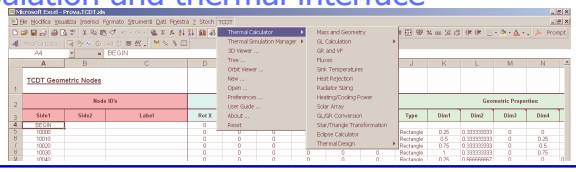


Thermal Calculator



The Thermal Calculator (THECAL) allows to:

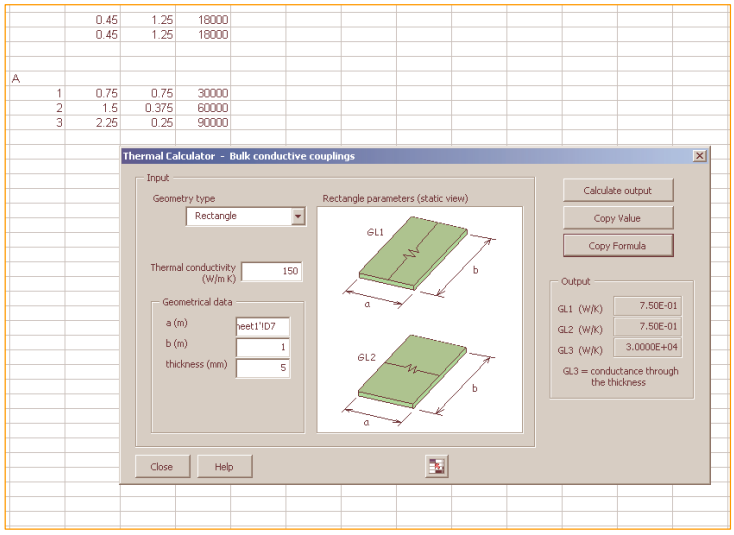
- Calculate Mass (M), Centre of Gravity, Moments of Inertia and thermal capacitances
- Calculate conductive couplings and contact conductance for simple geometrical configurations
- Calculate radiative conductors and external fluxes calculated for simple geometrical configurations
- Calculate sink temperatures, heat exchanged for nodes and group of nodes according to data in the DBsheet
- Select among possible Insulation and thermal interface



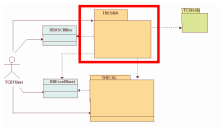
Linear Conductors Definition

Bulk Conductive Couplings

- THECAL Form
- THECAL Function
- TCDT Help

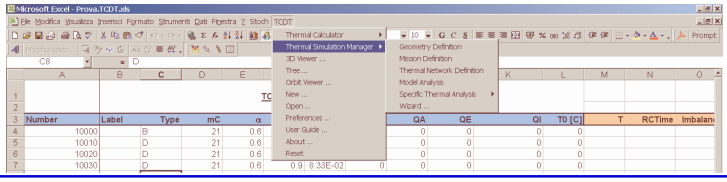


Thermal Simulation Manager



The Thermal Simulation Manager (THESMA) allows to:

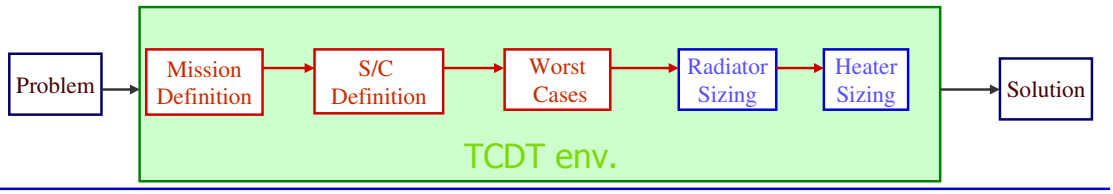
- Build geometrical and thermal mathematical models
- Create input files for the external tools
- Define missions, radiative and thermal analysis cases
- Run analysis cases with the external tools
- Retrieve the results of analysis cases previously performed
- Perform specific analysis and design tasks on pre-built geometrical/thermal typical configurations
- Perform parametric analyses (e.g. for extreme cases assessment)



Design Process with TCDT (1/7)

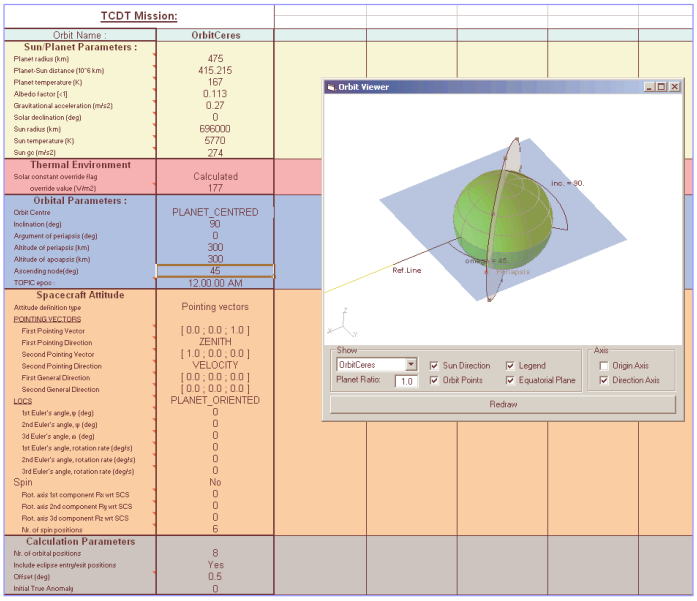
Preliminary design process with the THESMA

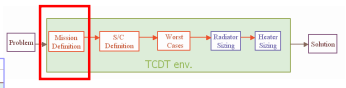
- Mission to Ceres for a S/C in a circular orbit
  - apoapsis/periapsis: 300 km
- Radiator and heater power sizing for an equipment mounted on +Z panel.
  - 15°C < Tequipment < 30°C
  - QIequipment
    - hot case = 200 watt
    - cold case = 100 watt
  - radiator decoupled from the rest of the S/C



Design Process with TCDT (2/7)

Mission Definition

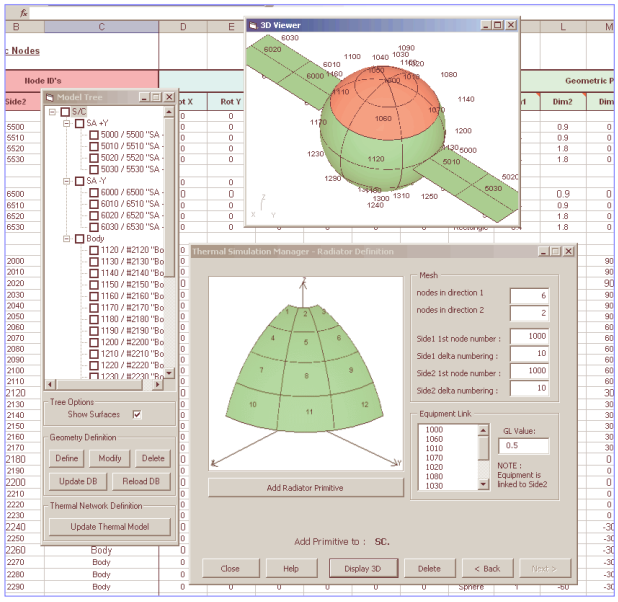




- Orbit Viewer
- Orbit Form
- Mission Worksheet

Design Process with TCDT (3/7)

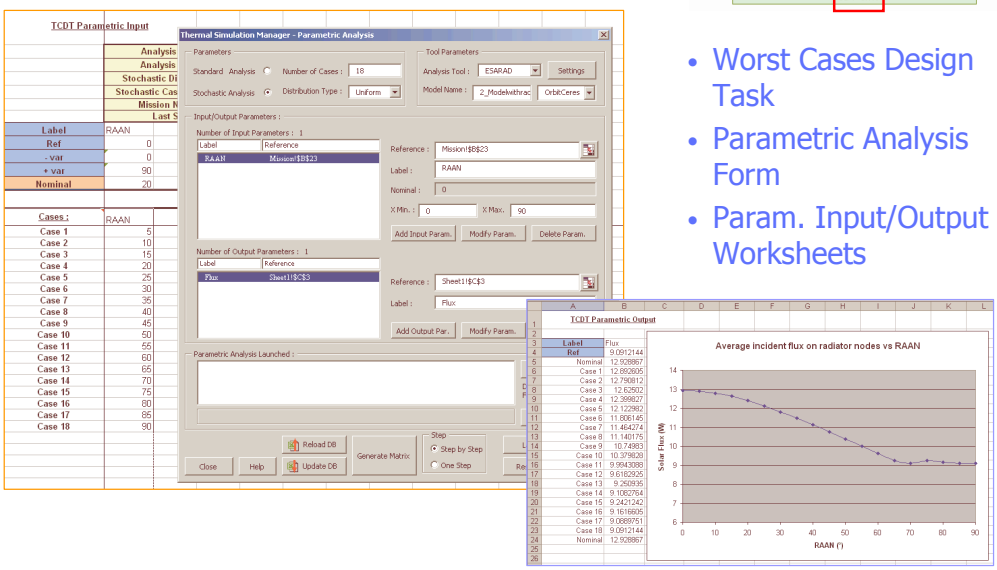
S/C Definition



- 3D Viewer
- Geometric Form
- Radiator Form
- Model Tree
- GNodes Worksheet
- TNodes Worksheet

Design Process with TCDT (4/7)

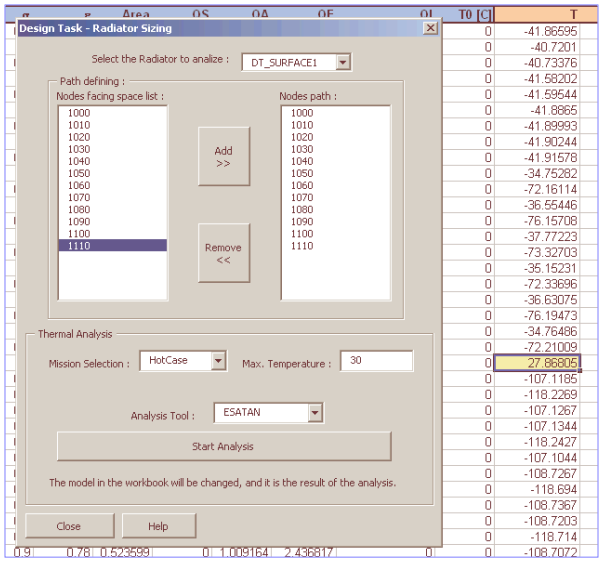
Worst Cases



- Worst Cases Design Task
- Parametric Analysis Form
- Param. Input/Output Worksheets

Design Process with TCDT (5/7)

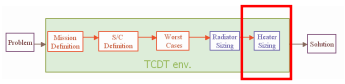
Radiator Sizing

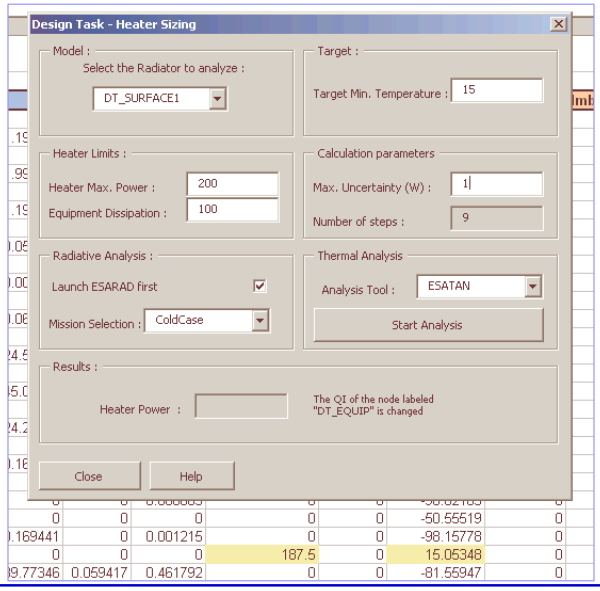


- Radiator Sizing Design Task
- GNodes Worksheet
- TNodes Worksheet
- Conductors Worksheet

Design Process with TCDT (6/7)

Heater Sizing

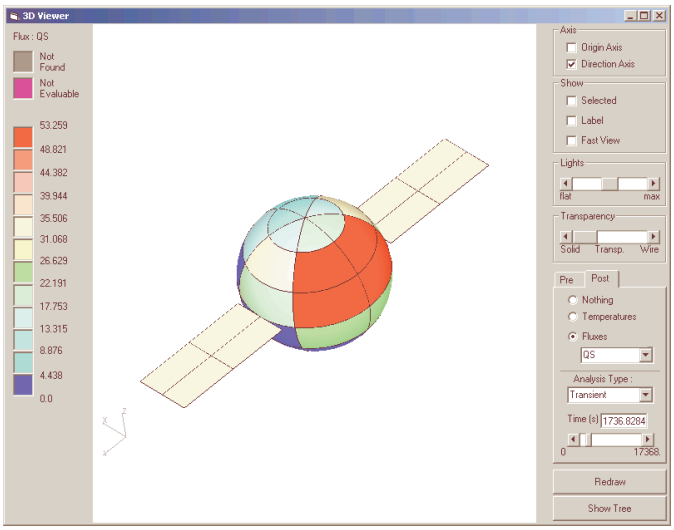




- Heater Sizing Design Task
- TNodes Worksheet

Design Process with TCDT (7/7)

Results Processing



- 3D Viewer
- Model Tree
- GNodes Worksheet
- TNodes Worksheet
- Results Worksheet
- Arrays Worksheet

Conclusions (1/3)

TCDT: easy and flexible environment for design investigation

Data collected in a single Excel workbook:

- Quick checks, updating and organisation
- Quick definition of tables and charts for presentations and documents
- Quick data organisation for rapid data exchange with other disciplines

Data used at the same time for model definition and elaborations:

- Reduction of risk of discrepancies between documentation and models
- Allowing a reliable speed up of thermal engineers activities

Possibility to manage different configurations:

- Quick design configuration evolution without any limit in the number of design options.

Conclusions (2/3)

TCDT: a new approach to analysis/design for thermal engineer

TCDT high-level functionalities:

- Predefined design tasks
- Predefined thermal/geometrical primitives
- Full capability to manage single, parametric and iterative analyses
- Advanced GUI for model and analysis checks

TCDT low-level functionalities:

- Possibility to define user design tasks
- Possibility to define any thermal-geometrical model
- Possibility to add user functions

Conclusions (3/3)

TCDT: lessons learnt and possible future development

lessons have been learnt for future activities:

- More code in VB environment (Compiled DLL) to improve performance
- VBA environment within Excel sometimes is not enough flexible and reliable

Useful and natural continuation for future activities:

- Development of ModelTree and 3DViewer
- Development of mission analysis versus a thermal/radiative analysis
- Further development of parametric analysis: stochastic analysis with different distributions, optimization procedures.
- Implementation of a material database.
- Further development of GL generator of THESMA.
- Implementation of other dedicated modules for results data processing.
- Implementation/integration of internal solvers.