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Thermal and Structures Division

Using ThermXL and EcosimPro for Fast Turn-Around Thermal Analysis

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Introduction

ESA supports the development of 3 tools with built-in solvers

- **ESATAN/FHTS** is a well-known and established standard. It is used for nearly all European Space Projects (phases A to D)
- **ThermXL** is an Excel based thermal spreadsheet launched in July 2000 at ICES. It is mainly designed for phase A/B studies and “what if” thermal analysis
- **EcosimPro** is a multi-disciplinary simulation tool based on OOM. It is mainly used for ECLS analysis but has potential for medium-size thermal and thermo-hydraulic analysis

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Objectives

- ThermXL is a new product. Its functionality was presented last year but not demonstrated on a real application
- EcosimPro was recently re-designed on top of C++ and opens up new ways of modelling thermal systems using an Object-Oriented approach
- Our objective today is to introduce these 2 “newcomers” and to pre-assess their potential and range of application to complement ESATAN/FHTS

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What is ThermXL?

- ThermXL is a thermal modelling environment which supports the thermal lumped parameter method
- Interface is based on the Microsoft Excel spreadsheet. The interest is to use all the flexibility of Excel to build a model and post-treat the results; copy/paste functionality, sorting, handling of linear and non-linear properties by formulas, Visual Basic language, plotting etc.
- Additional functionality is built-in the tool e.g. groups of nodes
- Designed for rapid conceptual and parametric studies (“What if…”)

What is ThermXL?

- Provides steady-state and transient solution routines
- Converted to C++ from the ESATAN SOLVIT and SLFWBK solvers
- Permits up to 254 nodes connected by up to 65500 GLs, 65500 GRs and 65500 GFs (limited by the performance of the machine)
- System requirements: Windows 95, 98, NT, Excel 97 (SR 2.0).
  The software is not yet ported on Windows 2000
- Distributed by ALSTOM: ftp://ftp.power.alstom.com/upload/ThermXL
  Free limited demo version is available

First application

Hypobaric plant growth chamber
(see Robert Lindner's presentation)

Second application

ThermXL and EcosimPro models developed for the purpose of this demonstration will be provided free on the ESTEC ftp server at

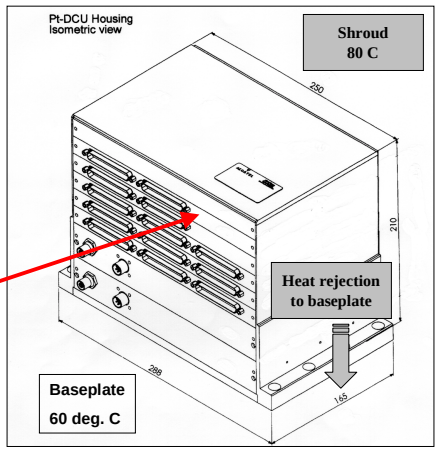
ftp.estec.esa.nl/pub/yc/Thermal_ECLS_Workshop2000

Second application - PTDCU in the LSS

The Platinum Data Collection Unit Equipment is part of the Temperature Data Acquisition System in the LSS (ESTEC)

Requirements

- **Verify** a Steady State HOT worst case during a review
- **Do it in "real time"!**
- Analyze and provide results to internal customer (testing)



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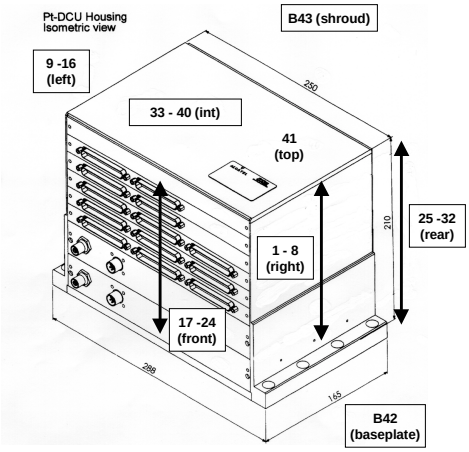
PTDCU / Thermal Modelling Steps

a/ Implement a global S.S. conduction model:

- **41** diffusive nodes
  - 4*8 = 32: lateral walls
  - 1: top wall
  - 8: internal PCBs
- **1** boundary node (baseplate)

b/ Implement the LSS shroud (**1** boundary Node) and GRs



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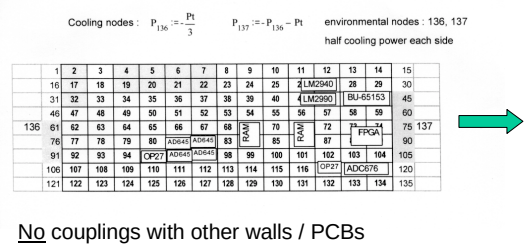
PTDCU / Thermal Modelling Steps

c/ Implement a **137** nodes detailed conduction model of the critical PTMB (PCB at the top which dissipates 6W - node 34 in the global model)

d/ Integrate this detailed model into the global model and compute the temperatures

Left Wall
(node 10)



Right Wall
(node 2)

No couplings with other walls / PCBs

PTDCU / Thermal Modelling Steps

Case ID	Analysis case	Solver	Dif. Nodes	Bound. Nodes	GLs	GRs	Dissipation (W)
a/	PTDCU Global (conduction)	Steady-State	42	1	66	0	44
b/	PTDCU Global (conduction/radiation)	Steady-State	42	2	66	33	44
c/	PTMB Detailed model (conduction)	Steady-State	135	2	259	0	6
d/	PTDCU/PTMB Detailed model	Steady-State	176	2	325	33	44

Tool retained: **ThermXL** - Reasons are:

- Model is easy to build (with Excel functionality)
- Easy and fast delivery of documentation to the customer
- No requirement for maintaining these models and ensure “long-term” configuration control
- Provides a good comparison case for EcosimPro (see later)

ThermXL Demonstration

ThermXL - Weaknesses

- Configuration control can be an issue. Difficult to track how the configuration has changed after several modifications
- Redundancy of information - In practice several analyses are run on the same model. The same model definition (nodes, conductors, powers) can be contained in several Excel files
- The tool does not interface with ESATAN
- Run-time performance is poor when compared to ESATAN or EcosimPro (could be improved by writing temperature arrays)
- Sub-models are not supported
- Very much dependent on Excel and Visual Basic / PC only

ThermXL - Strengths

- (Very!) easy and quick to build and check a model using the Excel built-in functionality.
- Adds functionality with groups of nodes and heat balance inspection
- Easy to document with parameters Worksheet, plots, pictures etc.
- An interface that your supplier or customer will understand
- Integrated programming language (Visual Basic)
- Access to the COM world
- ThermXL is also a very good training tool for your new engineers!

What is EcosimPro?

- EcosimPro is a multi-disciplinary tool providing a simulation layer (language and user interface) on top of C++
- Object-Oriented Modelling is particularly adapted when using the lumped parameter method and a **bottom-up approach** with clear **interfaces** defined between a unit and a (sub)system
- The tool combines the powerful capabilities of a true Object-Oriented Language with a reasonable level of complexity to define, execute and post-process models and analyses

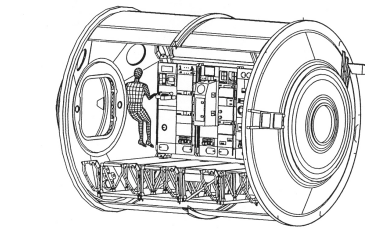
What is EcosimPro?

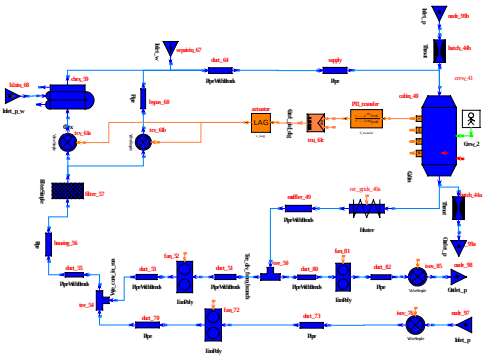
- System requirements: Windows 95, 98, NT, 2000, Millenium
  Visual Studio C++ is required.
  Smartsketch is an optional CAD 2D drawing package
- Distributed by EAI: http://www.ecosimpro.com for more details

What is EcosimPro?

- Designed initially to address ECLSS analysis e.g. Columbus

COLUMBUS Orbital Facility (COF)





Basic concepts of EcosimPro

The component (building brick of the tool) is defined by:

- A Public **interface**
  - PORTS (connection to other components)
  - DATA and Arguments

- A **Private** (hence "secure") part
  - Local variables
  - Relationships (Continuous or Discrete events)

The Component encapsulates in a single place interface, data and behaviour e.g. a node, a conductor, a Peltier, a fluid loop, a PID controller

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Basic concepts of EcosimPro

Just 2 of the advantages of the EcosimPro Language are:

1. To **inherit** one component from another e.g. all conductors are derived from a generic template with 2 interface PORTS.
   However, a linear conductor will have data and relationships that differ from a radiative conductor ➔ Using this approach saves code, facilitates testing and reduces the maintenance of your libraries

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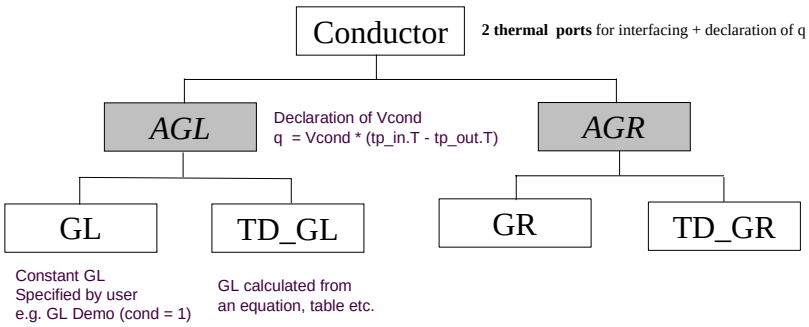
Basic concepts of EcosimPro



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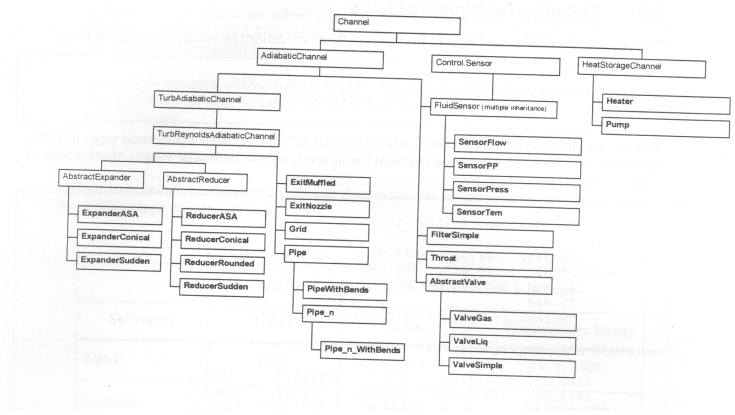
Basic concepts of EcosimPro



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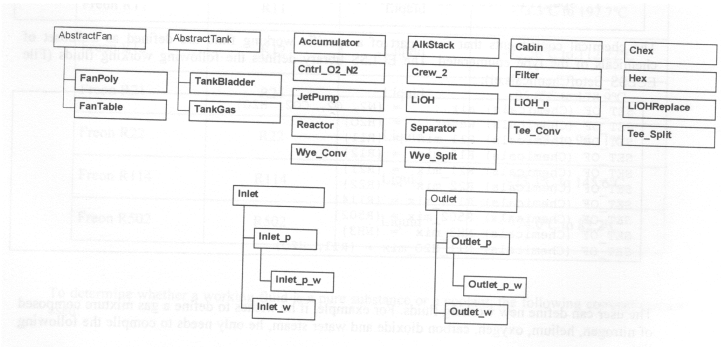
Basic concepts of EcosimPro



Basic concepts of EcosimPro

2. To facilitate a **modular** (system) approach with components that can be plugged-in together

   - Components are designed at **Unit level**, tested, possibly simplified (reduced) and integrated at a **system level** using their **interfaces** (PORTS)

   - The constraint is to define clearly the interfaces from the start and to maintain them through the analysis process

   - This is close to what we do in space thermal engineering!

EcosimPro Demonstration

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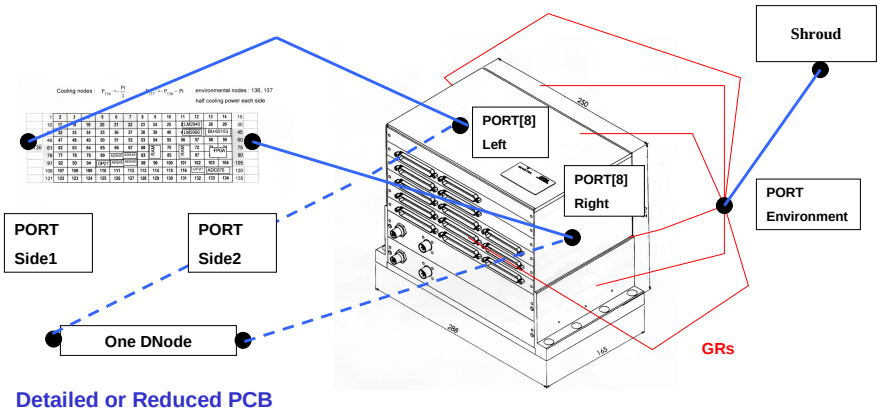
EcosimPro Demonstration



Detailed or Reduced PCB model(s) can be used

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EcosimPro - Weaknesses

- General difficulty in addressing radiation with an OOM approach - Radiation is not linked with a physical object (wall, plate, etc.)
- Objects (components) arrays are not supported e.g. it should be possible to use FOR (i = 0, i < nodes, i++) DNode D[i] (To = Tinit)
- Lists (collections) of objects are not supported. Would be useful to define groups of nodes and enable heat balance inspection
- The tool does not interface with ESATAN. A simple interface with ThermXL is currently prototyped but the real issue is to use all the power of ESATAN to handle large thermal networks e.g. ECLS
- The tool belongs to the PC/Microsoft World and is not running on Linux or Unix

EcosimPro - Strengths

- Nearly all the advantages of OOM with a clean language and user-friendly user interface
- Powerful equation handling and efficient solvers
- Components are easy to design and to extend (although some training is clearly necessary to start this task with efficiency - training courses are often organised by EAI to address this need)
- Very well adapted for testing a component at Unit level and to integrate it in a system
- Clean distinction between a model and the analysis run on a model
- Good error reporting and good built-in reporting/debug functionality