

# Status of some ESA supported activities in thermal, thermo-hydraulic and ECLS analysis

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Purpose: To brief you on some work that we have been carrying out and that we plan to initiate in the area of:

- **Thermal** analysis tools (ThermXL, ESATAN + new tools)
- **Thermo-hydraulic** analysis tools (FHTS, ALGOCAP)
- **ECLS** analysis tools (EcosimPro)
- **Distributed** simulation tools (DC using ESATAN as a server)
- **Methodologies** (stochastic approach, model reduction)

*Activities related to ESARAD, Data Exchange, OSS applicability & Harmonisation are not treated here → For info: Hans Peter de Koning and/or Charles Stroom*

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*Thermal analysis tools*

## ThermXL

(Industrial partners: ALSTOM & FSC)

Activities in 2001-2002:

- Functionality consolidation (slight issues from v1.0 corrected)
- Implementation of a new license mechanism
- New functionality provided with v2.0 (ESATAN/SINDA export, user results worksheet, API to execute solvers from VB etc.)
- Current developments include ESARAD import & sensitivity worksheet



*See ALSTOM presentation for details*

*Thermal analysis tools*

## Thermal Concept Design Tool

(ITT on EMITS beg. 2003)

- Intended as a specific environment to support pre-phase A, phase A & “what if” studies
- Will also be used for the ESTEC Concurrent Design Facility  
(ThermXL is currently used but lack high-level functionality)  
→ probably built using Excel
- Pre-built and customised “design modules” to execute a sequence of “jobs” automatically and transparently  
Example: radiator sizing may require the generation and management of a GMM and a TMM but this will be hidden for the user who will work on a high-level
- The idea is to use & integrate existing tools

*Thermal analysis tools*  
**Thermal Concept Design Tool (cont.)**

- Databases to quickly derive essential information  
Examples: thermo-optical properties, contact conductances, heat pipes / CPLs / LHPs conductances
- Standard mechanism to capture mission and temperature requirements
- Standard mechanism to feedback output of the thermal subsystem to other subsystems e.g. radiator areas, power budget
- To assess the possibility of building a “thermal design” database associated with mission type & spacecraft configurations

*Thermal analysis tools*  
**ESATAN**  
(Industrial partner: ALSTOM)

Activities in 2001-2002:

- Implementation of “simple” but useful functionalities requested for many years (cyclic solver, min/max routines etc.)
- Correction of a large number of bugs (> 20) that were making the users’ life difficult
- Implementation of FlexLM as a license mechanism
- New developments within v8.8 (fast-ESATAN, common block interface for nodal entities, heat balance convergence criteria, consolidation of user documentation etc.)



See *ALSTOM presentation for details*

## Open Source Post-Processing Tool for Thermal Data Using STEP/NRF

(Industrial Partners: ALSTOM + Consortium of users)

- Expected to be carried out by ALSTOM + Users (CNES + Primes + Subcontractors + Academia). Planned for mid. 2003
- Has been requested by the user community for many years as a key tool to complement the current suite
- The term “post-processing” has many meanings and can include different aspects such as plotting, heat balance inspection, support for test preparation/correlation, data model traceability through the life cycle of the analysis etc.
- Considerable resources have been deployed to develop specific & strategic functionality by Industry & Agencies.  
An open framework should thus be provided

## Open Source Post-Processing Tool for Thermal Data Using STEP/NRF (cont.)

- 2 levels of functionality:
  - Standard: API for database access using a STEP-NRF data model, plotting, comparison between analysis/test results, support for test engineering
  - Customised: To fulfill specific / proprietary needs of the users e.g. different model reduction algorithms modules that can be plugged-in to the environment
- Pilot project for the OSS approach. The IPR will belong to ESA (one-off development)

*Thermo-hydraulic analysis tools*

## FHTS

(Industrial partner: ALSTOM)

Activities in 2001-2002:

- Review of current mechanisms provided to define and use fluids properties and heat transfer correlations
- Correction of bugs as for ESATAN
- New functionality under investigation in response to request from Industry e.g. zero-flow solution for ALENIA
- Prototyping of FGENFI (two-phase transient solver) to support fluid in pseudo steady-state and improve performance



*See ALSTOM presentation for details*

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*Thermo-hydraulic analysis tools*

## ALGOCAP

(Industrial partner: OHB)

Activities in 2001-2002:

- Bibliographical review of algorithms used for the design and analysis of CPLs and LHPs
- Prototyping activities to investigate CPLs/LHPs simulation at system-level with a thermal solver (e.g. ESATAN) and without inside knowledge of the fluid loop components
- Executive report will be available soon



*See OHB presentation for details*

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*ECLS analysis tools*

## **EcosimPro**

(Industrial partner: Empresarios Agrupados)

Activities in 2001-2002:

- Version 3.2 with post-processing (plotting & roll-back), dependency tree, better integration with Smartsketck
- Independent industrial assessment of Astrium-GmbH (RFR project) → EcosimPro to replace PC ESATAN for ARES activities (see also the Astrium presentation at ICES 2002)
- New libraries for ECLS (MELISSA – see A. Rodriguez's presentation) and non ECLS activities (dedicated library for the ESTEC Propulsion Division)

*Distributed simulation tools*

## **DC & using ESATAN as a server**

(D. Alsina Orra, YGT at ESTEC + FSC + Simulation Section)

- Requirement for loose and distributed coupling of 2 or more applications (client-server approach)  
Examples: e.g. ECLS simulation requiring the use of an ESATAN model (ISS) or plug-in of thermal models in real-time simulators
- DC (using TCP/IP) was developed by FSC and released to ESA with Fortran 77, C, C++ APIs in 1997. (Had been little used since).
- D. Alsina's assessment of off-the-shelf technologies has lead to adapt DC and carry out prototyping tasks

*Distributed simulation tools*

## DC & using ESATAN as a server (cont.)

- Prototyping activities performed at ESTEC:
  - Distributed coupling of 2 ESATAN models on 2 platforms (SGI / Linux)
  - Encapsulation of the ATV thermal model in an EcosimPro component for system analysis (usage of ESATAN is transparent for the user). ESATAN ran on Linux and EcosimPro on PCWindows/NT
  - Plug-in of the SMART-1 & ATV models to Eurosim to assess feasibility of real-time simulation (some limitations were found but were not DC-related)

*Distributed simulation tools*

## DC & using ESATAN as a server (cont.)

- Continuation of prototyping tasks with implementation of a SOAP interface to pass firewalls
- Assessment to see if, in addition to ESA tools, DC can be provided at the lowest possible cost

Questions: 1. Is there some interest for such a tool?  
2. Which company would be happy to test it?

*Methodologies*

## Using a stochastic approach for thermal analysis

(ITT closed and consortium selected – Kick-off Nov. 2003)

- Develop a methodology based on the use of stochastic techniques to support the thermal analysis through the entire lifecycle of the TCS
- Selection of COTS or/and small software development
- Thorough assessment on practical and industrial cases
- A key aspect is to provide full visibility to the user community on the results obtained e.g. the Handbook is a key deliverable

*Methodologies*

## Model reduction algorithms

(S. Appel + O. Pin, ESTEC)

- Review of “physical” and “mathematical” algorithms used to generate interface thermal models for inclusion at higher-level (little has been published on the subject)
- Preliminary internal activities based on algorithms used in structural analysis (static reduction) with possibility to eliminate or/and to aggregate nodes
  - Seems to work well both for steady-state and transient.  
May produce GLs < 0 when aggregating nodes
- There seems to be as many opinions on the subject as users!  
The best way forward is unclear. Any suggestions?