

October 2005

ESATAN Thermal Suite

Product Status & Developments

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Introduction



- Present the product status
 - version in the field
 - what's new
- Forth-coming developments

- Define “What is the ESATAN Thermal Suite?”

- ESATAN Thermal Suite -



Introduction

ALSTOM

- The ESATAN Thermal Suite comprises of,
 - ESATAN

Thermal analysis
Flexible sub-modelling
Extensive library
External & template models
Parameter cases

- ESATAN Thermal Suite -

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Introduction

ALSTOM

- The ESATAN Thermal Suite comprises of,
 - ESATAN
 - FHTS

Fluid loop modelling
Fluid property database
Library of models
Air/vapour simulation
Special devices (CPL, pressure source....)

- ESATAN Thermal Suite -

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Introduction

ALSTOM

- The ESATAN Thermal Suite comprises of,

- ESATAN
- FHTS
- ABLAT

Ablation modelling

Charing elements

Non-charing element

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Introduction

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- The ESATAN Thermal Suite comprises of,

- ESATAN
- FHTS
- ABLAT
- ThermXL

Spreadsheet based thermal analysis

Sensitivity analysis

Group heat flow reporting

Direct access to MS ® Excel

- ESATAN Thermal Suite -

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Introduction

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- The ESATAN Thermal Suite comprises of,
 - ESATAN
 - FHTS
 - ABLAT
 - ThermXL
 - ThermNV

Model validation
Visual reporting and charting
Power post-processing

- ESATAN Thermal Suite -

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Introduction

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- The ESATAN Thermal Suite comprises of,
 - ESATAN
 - FHTS
 - ABLAT
 - ThermXL
 - ThermNV
- Announced December 2004
- All ESATAN customers moved to the new licence
 - no increase in cost to the customer

- ESATAN Thermal Suite -

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- Solver enhancements
- Solution monitor
- Sink Temperature
- Groups, Events & Aliases

- ESATAN 9.2 -

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Modelling enhancements: Groups - Events - Aliases

- Ability to define & refer to a group of nodes

```
$CONSTANTS  
$CHARACTER  
Group1 = '#1-Bad_middle';  
Group2 = '#4-10';  
#  
$VARIABLES2  
FLUX = FLUXGT|Group1, CURRENT, Group2, CURRENT;
```

- ESATAN 9.2 -

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Modelling enhancements: Groups - Events - Aliases

- Ability to define & refer to a group of nodes

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#
$VARIABLES2
FLUX = FLUXGT|Group1, CURRENT, Group2, CURRENT;
```

```
$EVENTS
$Timestep
Start_arcl_event = 500.0; # Start event for Arc1
End_arcl_event = 1250.0; # End event for Arc1

$VARIABLES1
IF(AFTER(Start_arcl_event, 0)
& AND BEFORE(End_arcl_event, 0)THEN
```

- Language updated to support named events
 - timestep and output events

- ESATAN 9.2 -



Modelling enhancements: Groups - Events - Aliases

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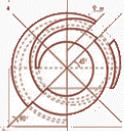
- Language updated to support named events
 - timestep and output events

- Ability to alias a node to a name
 - increase readability of model
 - decrease model dependence on nodal mesh

```
$ALIAS
# thermocouple1 = D103;
#
$CONDUCTORS
#
GL(Bar_end, 2) = 11.25;
#
GL(5, thermocouple1) = ...;

$VARIABLES1
IF(T:thermocouple1 .GT. 50.0D0)THEN
```

- ESATAN 9.2 -



- Heat transfer correlations
- Fluid property database
- Assessor functions

- ESATAN 9.4 -

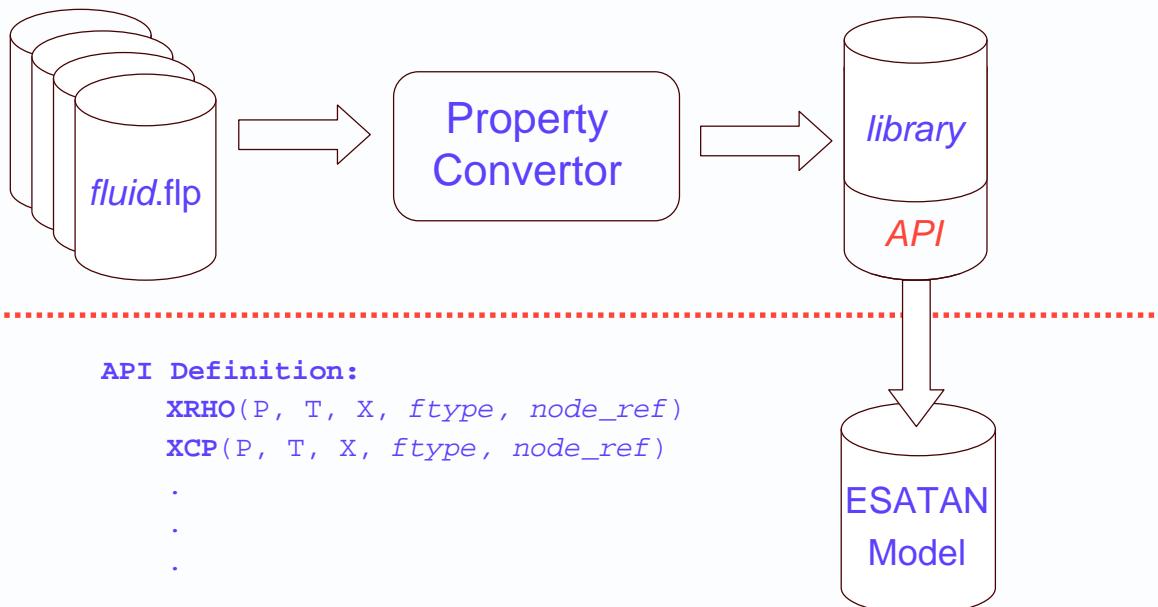


Fluid Property Interface: Introduction

- New architecture to define & access fluid properties
 - defined through external files (libraries - *.flp)
 - simple (readable) text based format
 - support for standard forms
 - constant values
 - interpolation
 - pressure and/or temperature dependent
 - fixed interval supported (for performance)
 - procedural definition (Fortran + reserved keywords)
- Generic ESATAN facility



Fluid Property Interface: Overview of Process



- ESATAN 9.4 -



Fluid Property Interface: Language

- Defined by,

fluid type (e.g. water, ammonia, *myFluid*)

property (e.g. cp, rho, ...)

region (e.g. liquid, saturated liquid, two-phase, ...)

```
$FLUID WHISKY  
#  
$RHO  
$LIQUID  
$. . .  
$SAT_LIQ  
$. . .  
$TWO_PHASE  
PROC  
RHO = 1.0 / ((1.0 - X) * RHO1 + X * RHO2)  
END_PROC  
#  
$SAT_VAP  
# Celsius  
FINTRP1(T, 1)  
5.0E00, 9.1E-3, 1.0E01, 1.2E-2, 1.5E01, 2.0E-2, 2.0E01, 2.7E-2,  
2.5E01, 4.5E-2, 3.0E01, 6.2E-2, 3.5E01, 8.3E-2, 4.0E01, 1.0E-1,  
5.0E01, 1.4E-1, 6.0E01, 1.8E-1, 7.0E01, 2.2E-1, 8.0E01, 2.5E-1,  
9.0E01, 2.9E-1, 1.0E02, 3.3E-1, 1.2E02, 3.9E-1, 1.4E02, 4.7E-1;  
#  
$VAPOUR  
$. . .  
$CP
```

- ESATAN 9.4 -



ESATAN Accessor/Get Functions

- General method to access ESATAN data
 - node data (e.g. temperature, pressure, ...)
 - control constant value (temperature, pressure offset, ...)
- Especially useful for external Fortran routines
 - for example, heat transfer coefficient definition

```
"      DOUBLE PRECISION FUNCTION MYHTC(FNODE, TNODE)
#
# Get fluid node entities
#
#      DIA = GETFD(FNODE) # Hydraulic diameter
#      PRESS = GETP(FNODE) # Pressure
#      TEMP = GETT(FNODE) # Temperature
#
# Calculate fluid properties
#      SPHT = XCP(PRESS, TEMP, QUALT, FTI, FNODE)
#      CND = XCOND(PRESS, TEMP, QUALT, FTI, FNODE)
#
# Mungo correlation
#      HTC = 0.5D0 * (RE ** 0.2D0) * (PR ** 0.6D0) * CND / DIA
#      &      * (ABS(TWALL - TEMP) ** 0.03D0)
#"
```

- ESATAN 9.4 -



- Improved interface
- Enhanced grouping
- Radiative data import
- Improved visualisation

ThermXL 4.2

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- ESATAN Thermal Suite -



Improved interface layout

Screenshot of Microsoft Excel showing the ThermXL ribbon menu. The 'ThermXL' tab is selected, and the 'Preferences...' option is highlighted.

The worksheet contains several sections of data:

- ThermXL Conductors**: A section with two rows of headers: "Label", "First Node", and "Second Node".
- ThermXL GLs**: A section with three rows of headers: "Label", "First Node", "Second Node", "Value", and "Heat Flow".
- ThermXL GRs**: A section with one row of headers: "Label", "First Node", "Second Node", "Value", and "Heat Flow".
- ThermXL GFs**: A section with two rows of headers: "Label", "First Node", "Second Node", "Value", and "Heat Flow".

The right side of the screen shows a watermark for "ESATAN FH1 thermal analysis".

- ThermXL 4.2 -

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Screenshot of Microsoft Excel showing the ThermXL ribbon menu. The 'ThermXL' tab is selected, and the 'Preferences...' option is highlighted.

The worksheet contains several sections of data, identical to the previous screenshot.

A new window titled "ThermXL Preferences Selector" is displayed, containing the following settings:

- Temperature Display Units: Celsius
- Stefan Boltzmann Constant: 5.670510E-08
- Basis For Radiative: Radiative

- ThermXL 4.2 -

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Enhanced Grouping facility

| C24 | | | |
|----------------------|--------------------------------|------|---|
| A | B | C | D |
| ThermXL Nodes | | | |
| ThermXL | | | |
| Group | Number Label | Type | |
| 4 SERVICE_MODULE | 101 MLI battery cone | D 0 | |
| 5 SERVICE_MODULE | 111 MLI battery bottom disc | D 0 | |
| 6 SERVICE_MODULE | 121 MLI battery inner cylinder | D 0 | |
| 7 BATTERY_RADR | 151 Battery Radiator face | D 2 | |
| 8 BATTERY_RADR | 152 Battery Radiator face | D 8 | |
| 9 ARRAY | 201 Solar Array Boom | D 0 | |
| 10 ARRAY | 251 Solar Array | D 0 | |
| 11 ARRAY | 261 Solar Array | D 0 | |

- ThermXL 4.2 -



Enhanced Grouping facility

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|----------------------|--------------------------------|------|---|
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| 8 BATTERY_RADR | 152 Battery Radiator face | D 8 | |
| 9 ARRAY | 201 Solar Array Boom | D 0 | |
| 10 ARRAY | 251 Solar Array | D 0 | |
| 11 ARRAY | 261 Solar Array | D 0 | |

| | | | | | | | | | | | | |
|----|------------------|------------------------|------------------------|----------|-----------------------|--------|---------|---------------|------------|-----------|---------|------|
| 16 | ThermXL Group | BATTERY_RADR | | | | | | | | | | |
| 17 | Group Properties | Constituent Node | 151,152 | | | | | | | | | |
| 18 | | Label | Type | mC | s | e | Area | BS | BA | BE | BI | |
| 19 | Current (S) | BATTERY_RADR | D | 1.19E+04 | 0.80 | 0.83 | 154E+00 | 0.59E+01 | 140E+00 | 4.29E+01 | 150E+00 | |
| 20 | | Group Temperatures (C) | | | Sink Temperatures (C) | | | Coupling Sums | | | | |
| 21 | Time | T Arith. Mean, T mC | Weighted Area Weighted | Mis. T | Mis. T | Max. T | Min. T | Body Rad's | Body Rad's | Radiative | Linear | |
| 22 | Current (S) | -2.33 | -6.11 | -8.12 | -15.04 | 10.26 | -41.67 | -42.04 | -63.08 | ZGPs | ZGLs | ZGPs |
| 23 | | | | | | | | | | | | |
| 24 | | | | | | | | | | | | |
| 25 | | | | | | | | | | | | |
| 26 | | | | | | | | | | | | |
| 27 | | | | | | | | | | | | |
| 28 | | | | | | | | | | | | |

- ThermXL 4.2 -



Enhanced Grouping facility

The screenshot shows the ThermXL 4.2 software interface. At the top, there's a toolbar with various icons. Below it is a menu bar with 'C24' selected. The main window has several tabs: 'ThermXL Nodes' (selected), 'ThermXL Groups', 'ThermXL Properties', and 'ThermXL Results'. The 'ThermXL Nodes' tab displays a table of nodes with columns for Group, Number, Label, and Type. The 'ThermXL Groups' tab shows a group named 'BATTERY_RADR' containing nodes 151 and 152. The 'ThermXL Properties' tab shows properties for 'BATTERY_RADR' like Current (SS) and Group Properties. The 'ThermXL Results' tab displays 'ThermXL Inter Group Heat Flows' with a table showing heat flows between groups over time.

| ThermXL Inter Group Heat Flows | | | | | | |
|--------------------------------|-------------------|-------------------|------------|-----------|--|--|
| Time | Group #1 | Group #2 | Heat Flows | Net | | |
| Current (SS) | ARRAY | BATTERY_RADR | -2.56E+01 | -2.56E+01 | | |
| | ARRAY | CRYORAD | -8.00E-03 | -8.00E-03 | | |
| | ARRAY | DOWNLINK | -2.45E-01 | -2.45E-01 | | |
| | ARRAY | PAYOUTLOAD_MODULE | -9.11E+00 | -9.11E+00 | | |
| | BATTERY_RADR | CRYORAD | -4.33E+01 | -4.33E+01 | | |
| | BATTERY_RADR | DOWNLINK | 3.65E-05 | 3.65E-05 | | |
| | BATTERY_RADR | PAYOUTLOAD_MODULE | 4.78E-03 | 4.78E-03 | | |
| | BATTERY_RADR | SERVICE_MODULE | -5.47E+01 | -5.47E+01 | | |
| | CRYORAD | DOWNLINK | 5.78E-01 | 5.78E-01 | | |
| | CRYORAD | PAYOUTLOAD_MODULE | 1.34E+01 | 1.34E+01 | | |
| | DOWNLINK | PAYOUTLOAD_MODULE | 4.74E+01 | 4.74E+01 | | |
| | DOWNLINK | SERVICE_MODULE | -6.70E+03 | -6.70E+03 | | |
| | PAYOUTLOAD_MODULE | SERVICE_MODULE | 4.32E+01 | 4.32E+01 | | |

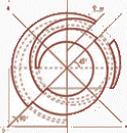
- ThermXL 4.2 -

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The screenshot shows the ThermXL 4.2 software interface. On the left is a vertical menu bar with options like 'ThermXL Enable...', 'Select Solver: Steady State', 'Manage Radiative Data' (which is expanded to show 'Import Radiative CSV Data...', 'Import Radiative Data from ESARAD...', and 'Link to Radiative Data...'), 'Export', 'Preferences...', 'User Guide...', 'License...', and 'About ThermXL...'. The main workspace is titled 'thermal analysis' and contains a table with several rows of data. At the bottom, there's a status bar with 'October 2005', 'Product Status 2005', and '14'.

- ThermXL 4.2 -

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Radiative Data Import

The screenshot shows the ThermXL software interface. On the left, a vertical menu includes 'Manage Radiative Data' and 'Import Radiative CSV Data...'. The main window displays an Excel spreadsheet titled 'ThermXL CSV Version' with data such as:

| | A | B | C | D | E | F | G | H |
|----|------------------------|--------------------------|-------|----------|------|-------|----------|------|
| 1 | ThermXL Radiative Data | | | | | | | |
| 2 | | ThermXL | | | | | | |
| 3 | ThermXL CSV Version | | | | | | | |
| 4 | generated_by | user_name | | | | | | |
| 5 | model | Alstom_Sat_Tutorial5_Out | | | | | | |
| 6 | radiative_case | radiative_case_name | | | | | | |
| 7 | timestamp | 23/06/2005 23:20:28 | | | | | | |
| 8 | | | | | | | | |
| 9 | node_table | Number | Label | Type | mC | alpha | epsilon | Area |
| 10 | 101 | MU battery | O | 0 | 0.43 | 0.7 | 3.045239 | |
| 11 | 111 | MU battery | O | 0 | 0.43 | 0.7 | 1.602212 | |
| 12 | 121 | MU battery | O | 0 | 0.43 | 0.7 | 0.879646 | |
| 13 | 151 | Battery RaO | | 2975.28 | 0.05 | 0.63 | 0.364845 | |
| 14 | 152 | Battery RaO | | 8923.264 | 0.05 | 0.63 | 1.154535 | |
| 15 | 201 | Solar Array | O | 0 | 0.09 | 0.8 | 0.376991 | |
| 16 | 251 | Solar Array | O | 0 | 0.74 | 0.82 | 24 | |
| 17 | 261 | Solar Array | O | 0 | 0.43 | 0.7 | 24 | |
| 18 | 301 | PLM body | O | 0 | 0.43 | 0.7 | 4 | |
| 19 | 311 | PLM body | O | 0 | 0.43 | 0.7 | 8 | |
| 20 | 321 | PLM body | O | 0 | 0.43 | 0.7 | 8 | |

- ThermXL 4.2 -

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Improved visualisation

The screenshot shows the ThermXL software interface. A red arrow points to the 'GFF file' button in the toolbar. A modal dialog box titled 'ThermXL Neutral Format (GFF) File Output' is displayed, containing:

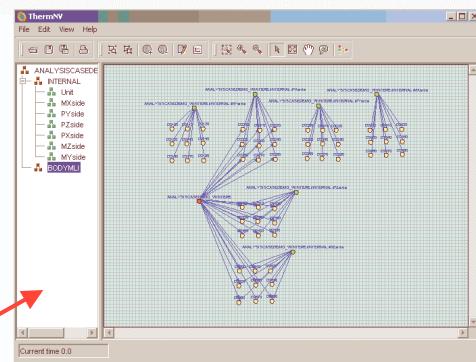
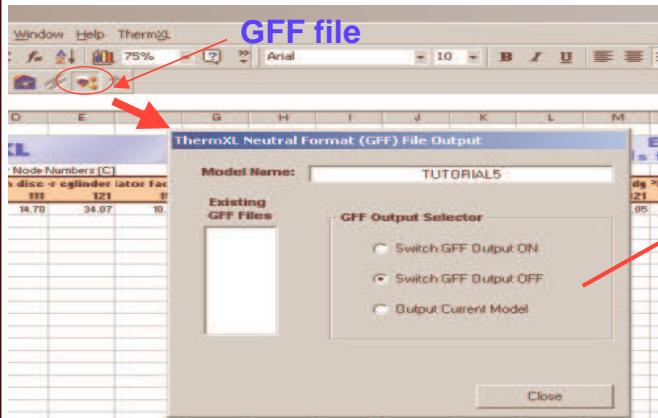
- Model Name: TUTORIAL5
- GFF Output Selector:
 - Switch GFF Output ON
 - Switch GFF Output OFF
 - Output Current Model
- Close button

- ThermXL 4.2 -

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Improved visualisation



- ThermXL 4.2 -

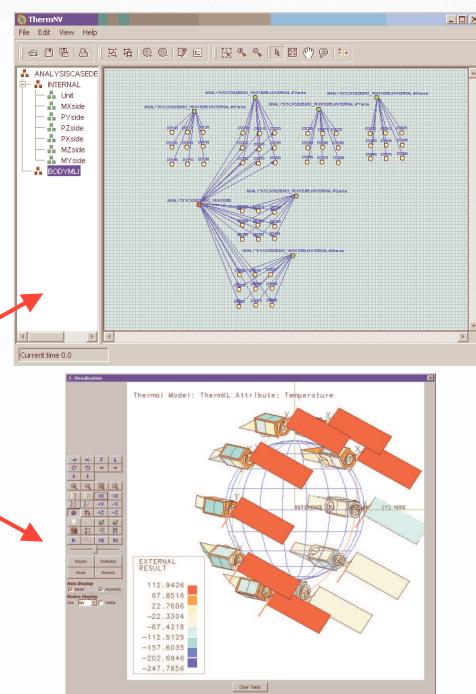
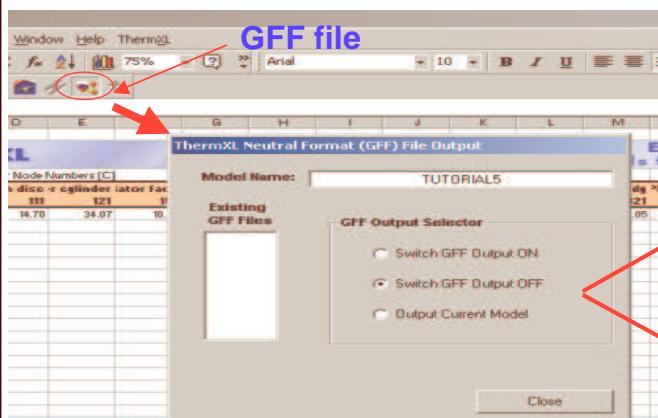
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Improved visualisation

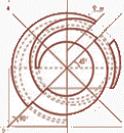


- ThermXL 4.2 -

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ESATAN / ThermNV 1.0 - December 2004

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- Major development 2004
- Announced ECLS 2004
 - “alpha” version handed out
 - request for feedback made
 - excellent response, with many requests & comments
 - extensive development in response
- December 2004
 - released as part of the ESATAN Thermal Suite
- Thank you

- ESATAN Thermal Suite -

October 2005

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Product Developments

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- What's next ? -

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ESATAN / FHTS Solver Developments

- Steady-state humidity simulation ✓
- Single-phase transient humidity solution
 - fltnf, fltns and flmts extended to handle wet air
 - hydraulic steady-state assumed (P & W)
 - water vapour inertia term included
 - condensing heat exchange element (CHX) compatible
- Implementation complete, ready for release

- ESATAN 9.6 -



ESATAN Scalability & Performance

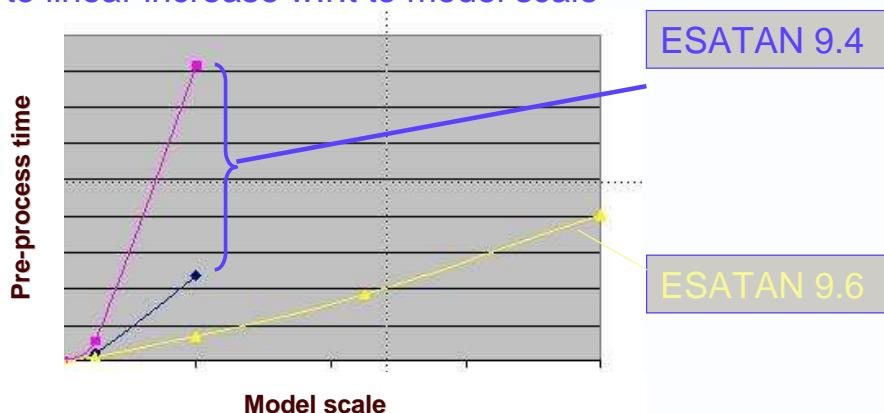
- Target set to handle models of order
 - 300,000 thermal nodes
 - 7,000,000 conductors
- Investigation performed, identified
 - intrinsic limits
 - FORTRAN generation/compilation step
 - pre-processor optimisation

- ESATAN 9.6 -



ESATAN Scalability & Performance

- Scaling of pre-process w.r.t nodes, conductors & arrays
 - performance dramatically improved
 - reduced to linear increase w.r.t to model scale



- Implementation complete, ready for release

- ESATAN 9.6 -



ESATAN Parametric Analysis

- Parametric analysis forms the basis of,
 - sensitivity analysis
 - design optimisation
 - test correlation
 - stochastic analysis
- Strength of ESATAN
 - model easily parameterised
 - \$PARAMETERS case functionality
- Batch solver

- ESATAN 10 -



ESATAN Parametric Analysis

Strategic Development:

- Enhance ability to perform parametric analysis
 - easy scaling & setting of entities/groups of entities
 - e.g. all conductors connected to a given node
 - efficient process
 - easy to generate series of cases
 - e.g variation of capacitance given a min/max or series
 - ease of reporting & post-processing
 - management of process

- ESATAN 10 -



Thermal Network Viewer - ThermNV 2



to be presented in the Afternoon

ThermNV 2

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- ThermNV 2 -



Summary

ALSTOM

- Presented current products in the field
 - ESATAN 9.4 [including FHTS & ABLAT]
 - ThermXL 4.2
 - ThermNV 1.0
- New ESATAN Thermal Suite licensing
- Outlined our current developments
 - ESATAN 9.6 - release end 2005
 - scalability & performance improvements
 - transient humidity simulation
 - ESATAN 10 - release 2nd quarter 2006
 - parametric analysis

- software.support@power.alstom.com -

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