

Tools For Flexible And Rapid Thermal Analysis And Design

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Danilo Lazzeri

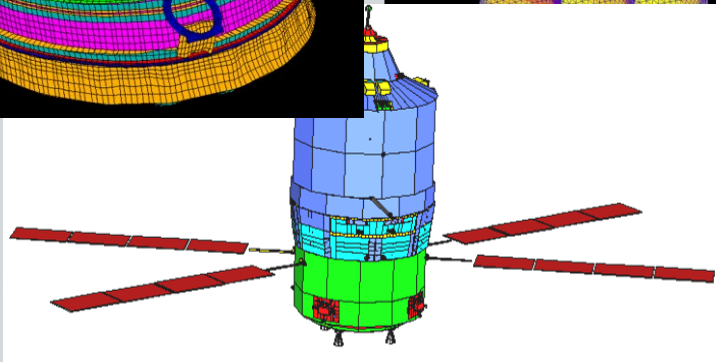
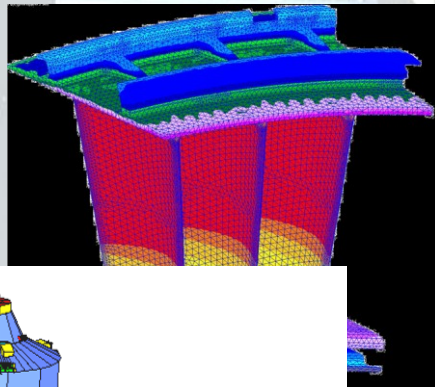
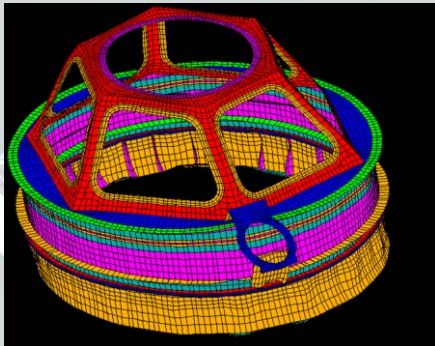
Blue GROUP, Torino, Italy



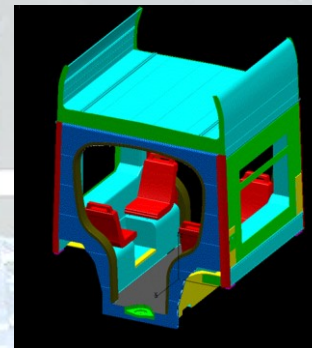
1st International Convention of Technologies of the Frontier,
Medieval Castle of Moncrivello (VC), Italy - April 1st 2006

BLUE GROUP - Engineering & Design

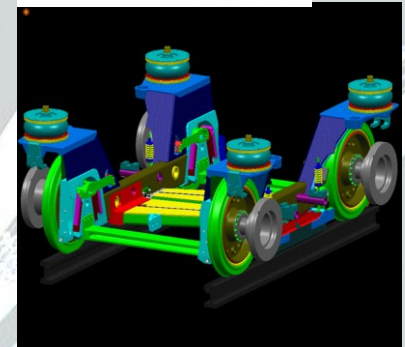
Aerospace



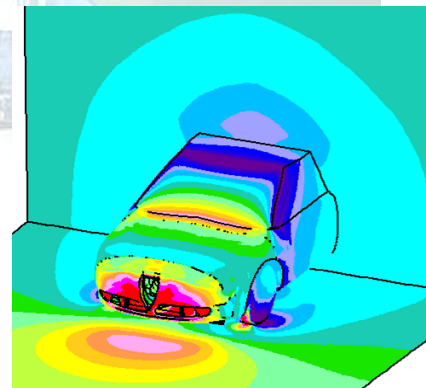
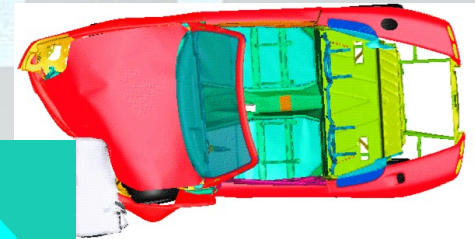
Railway



FIREMA Trasporti



Automotive



THERMAL CONTROL SYSTEM (TCS)

TARGET:

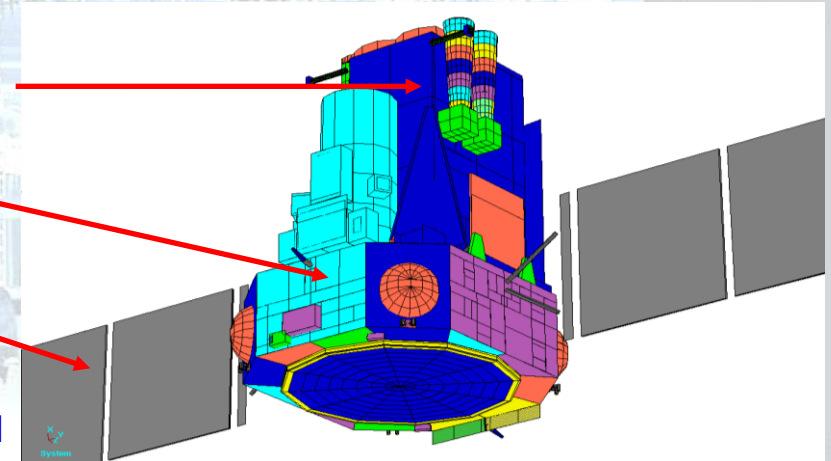
- Maintain temperatures levels to avoid damage and allow operability
- Minimise temperature fluctuations and thermal cycling of components to limit ageing.

Classical electronics equipment [-10°C ; +40°C]

Battery [0°C ; +20°C]

Propulsion system [+10°C ; +50°C]

Solar array [-190°C ; +120°C]

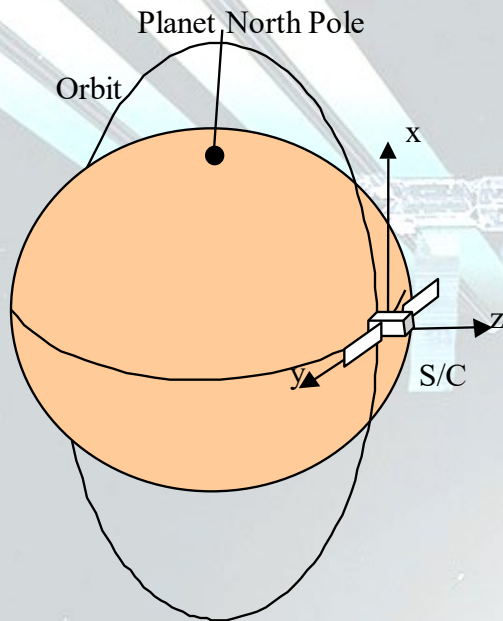


High Temperatures: 400°C to 1600°C for thermal protection

Cryogenics: Earth observation IR Detectors in the range 50 to 100K,

TCS DEPENDENCIES

Mission requirements



Payload characteristics

- Orbit
- Attitude

External configuration:

- location of sensors
- location of solar arrays
- location of antennas
- **worst thermal cases**
- **location of radiators**

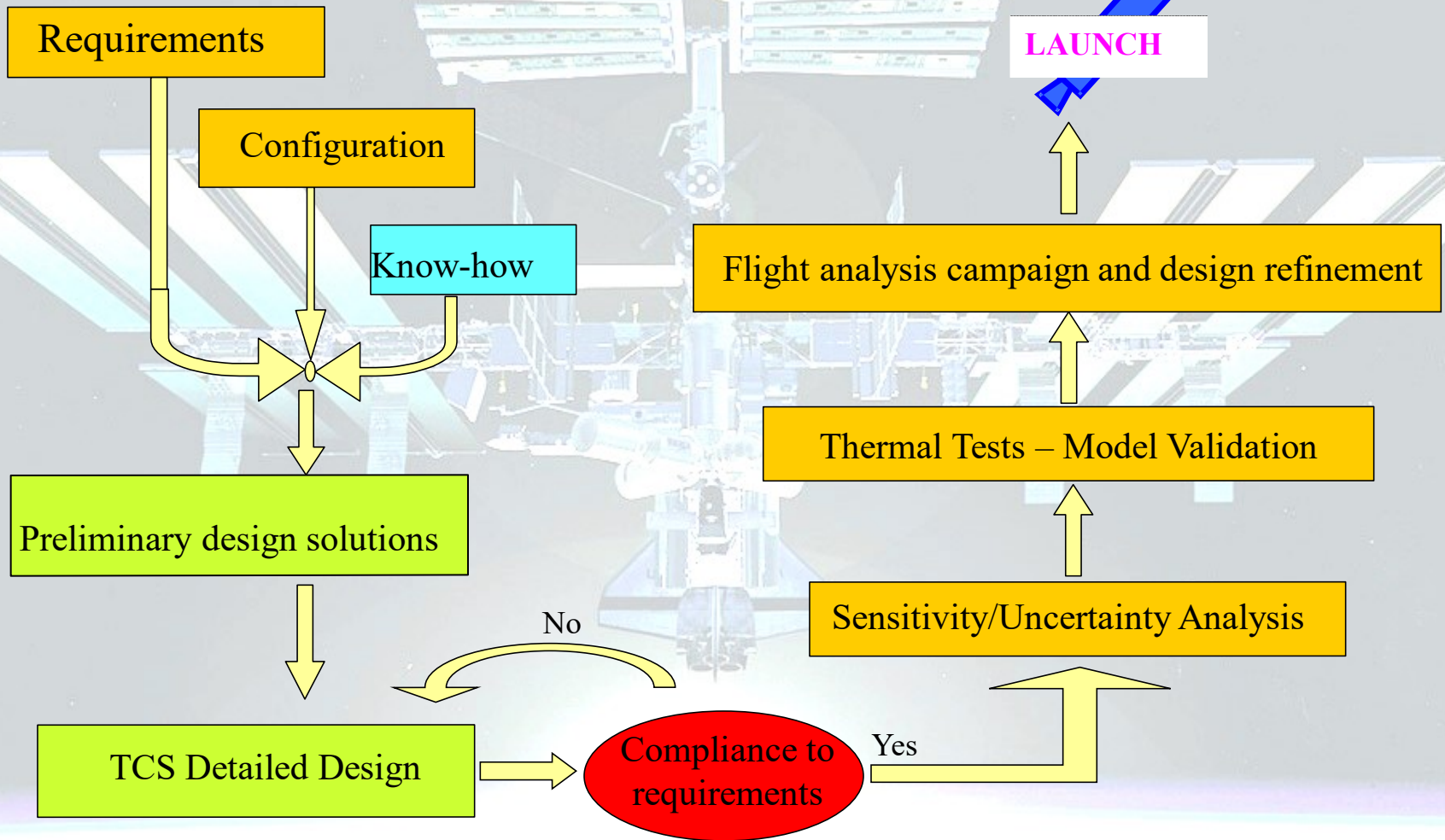
Internal configuration:

- structure
- tanks
- batteries
- large equipment
- **heat paths**

Other S/S

- Power
- Structure
-

TCS DEVELOPMENT



PRESSURE TO IMPROVE THE PRESENT SCENARIO

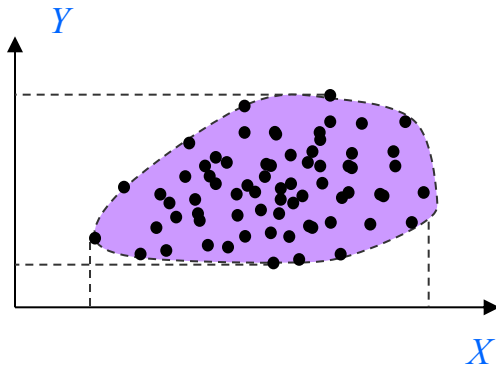
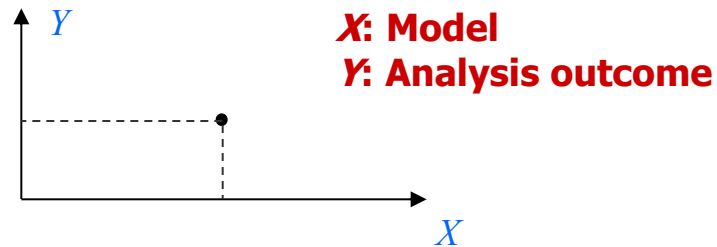
- **INCREASING COMPLEXITY** of space system and missions;
- Achieve design with **LOWER COSTS IN SHORTER TIME**;
- **DECREASING COMPUTATIONAL COSTS**;
- Awareness of limits in consolidated approach:
 - frequent **OVER-DESIGN**;
 - **TESTS AND CORRELATION COSTS**;
 - **LIMITED FLEXIBILITY** to accommodate design changes;

METHODS & TOOLS FOR IMPROVEMENTS

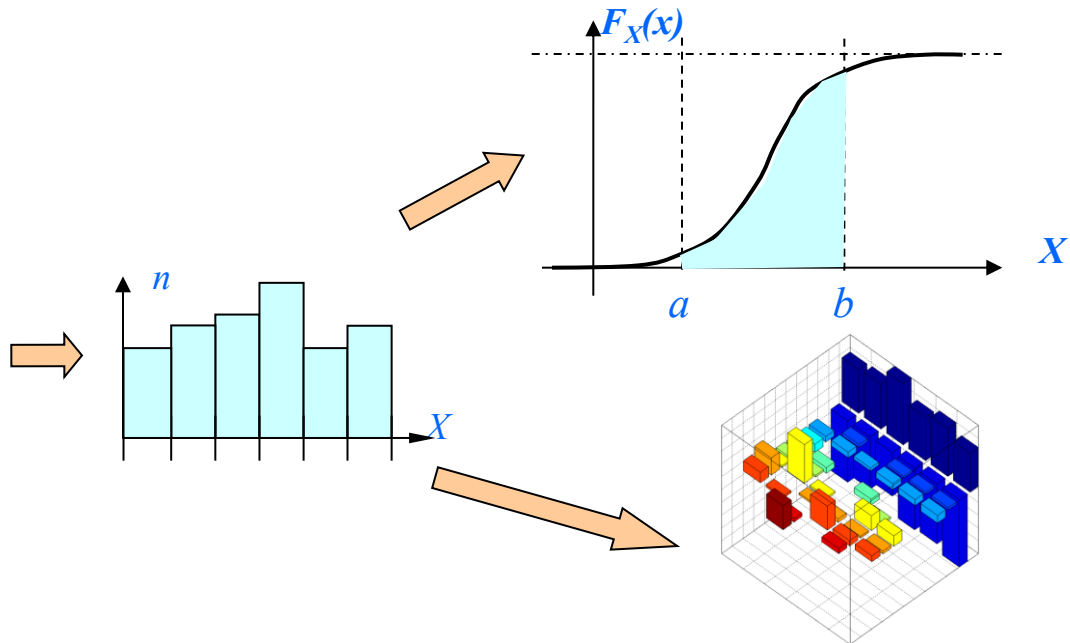
- Stochastic ANALYSIS & DESIGN
- Stochastic Optimisation
- Multidisciplinary ANALYSIS & DESIGN
- Integrated ANALYSIS & DESIGN Environment

STOCHASTIC ANALYSIS & DESIGN

Stochastic Models vs. Deterministic Models



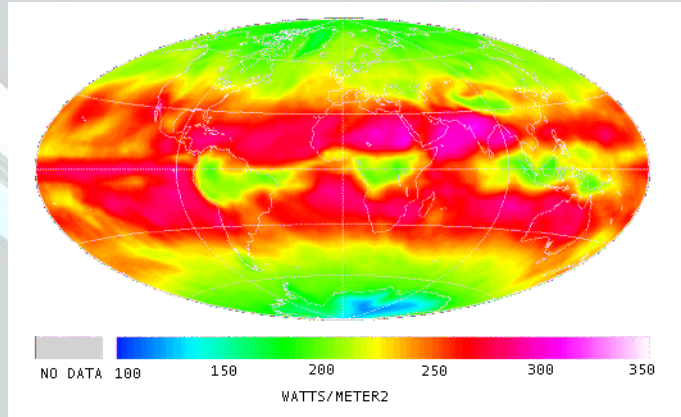
X: Models
Y: Analysis outcomes



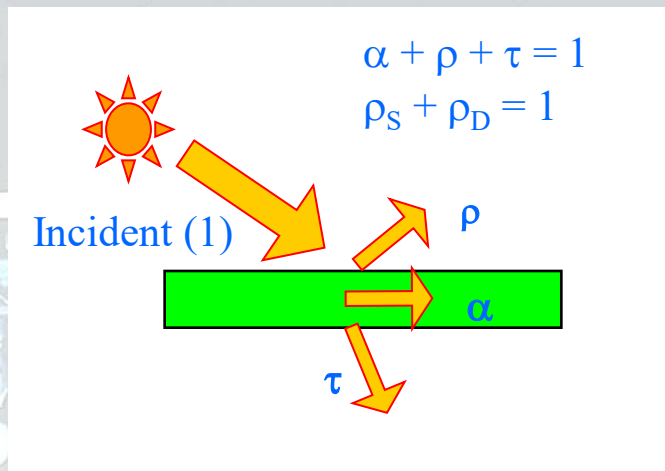
STOCHASTIC ANALYSIS & DESIGN

Parameters Inaccuracy/Variation management

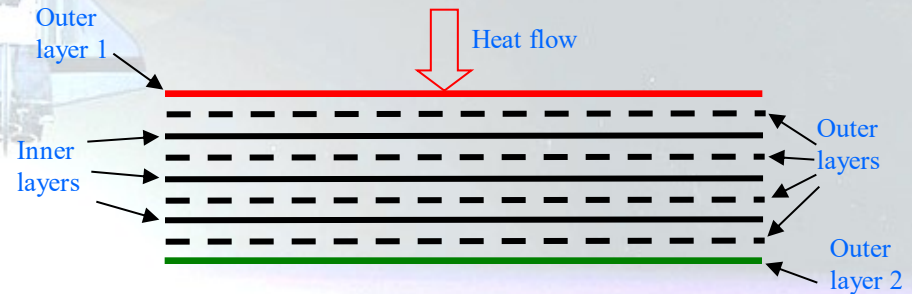
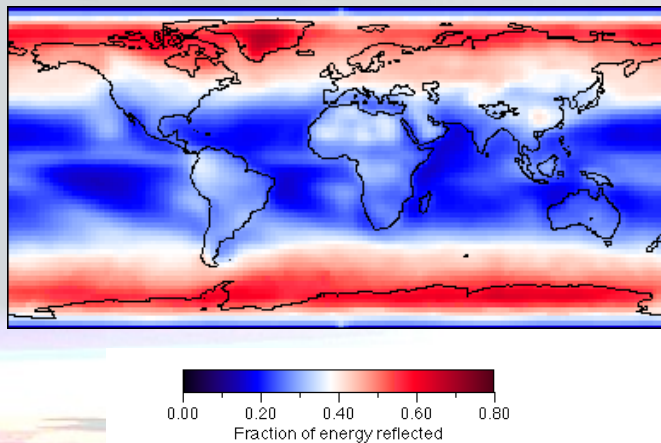
Planet Radiation



Solar Optical Properties



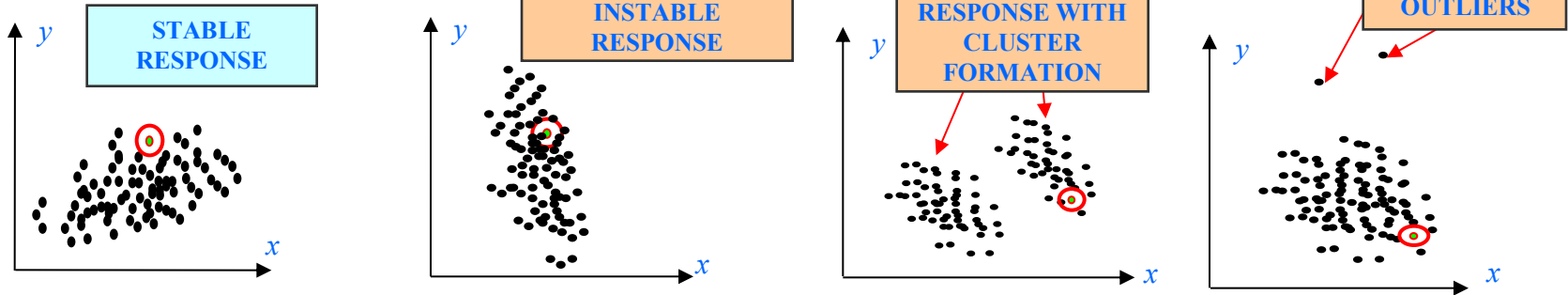
Planet Albedo Factor



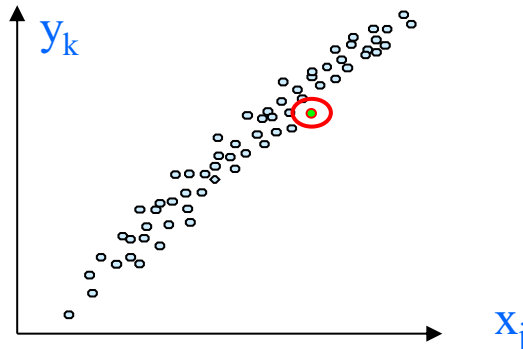
MLI Conductance

STOCHASTIC ANALYSIS & DESIGN

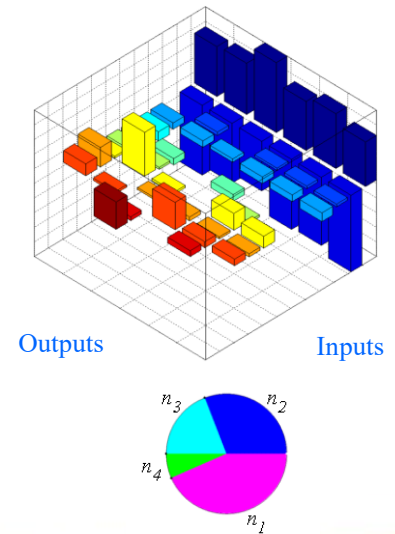
Design Robustness Assessment



Design Sensitivity Assessment

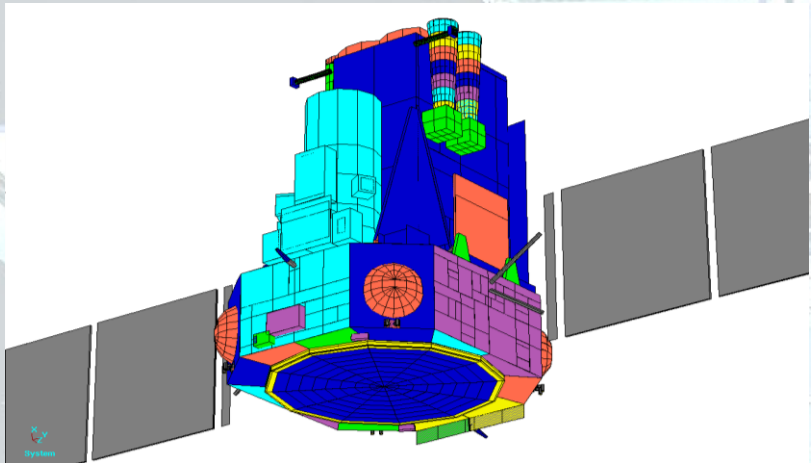


Input/Output correlation Analysis

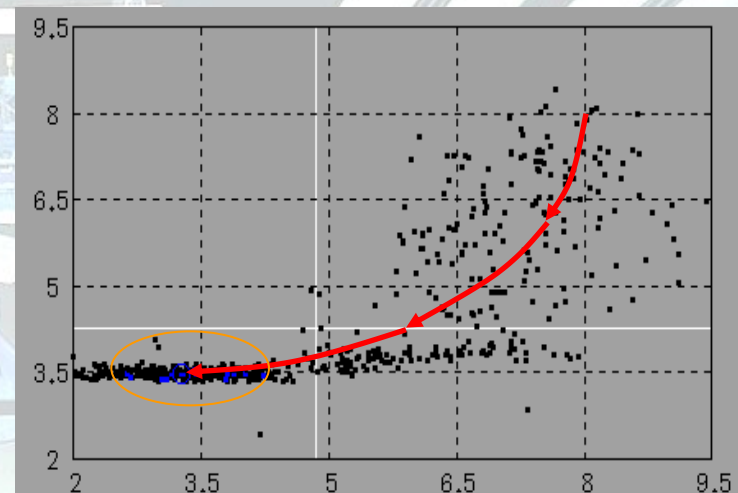


STOCHASTIC ANALYSIS & OPTIMISATION

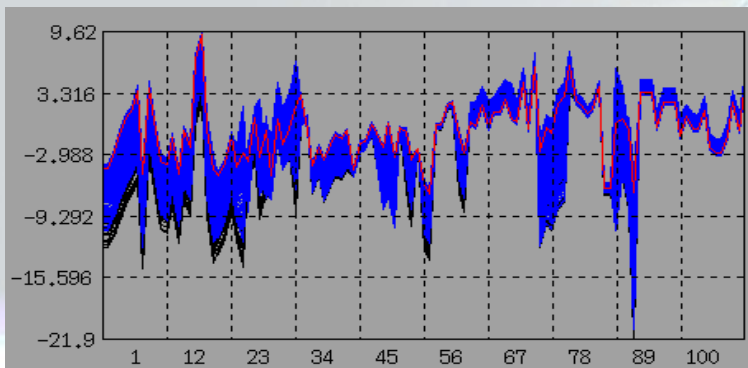
Automatic TEST Correlation



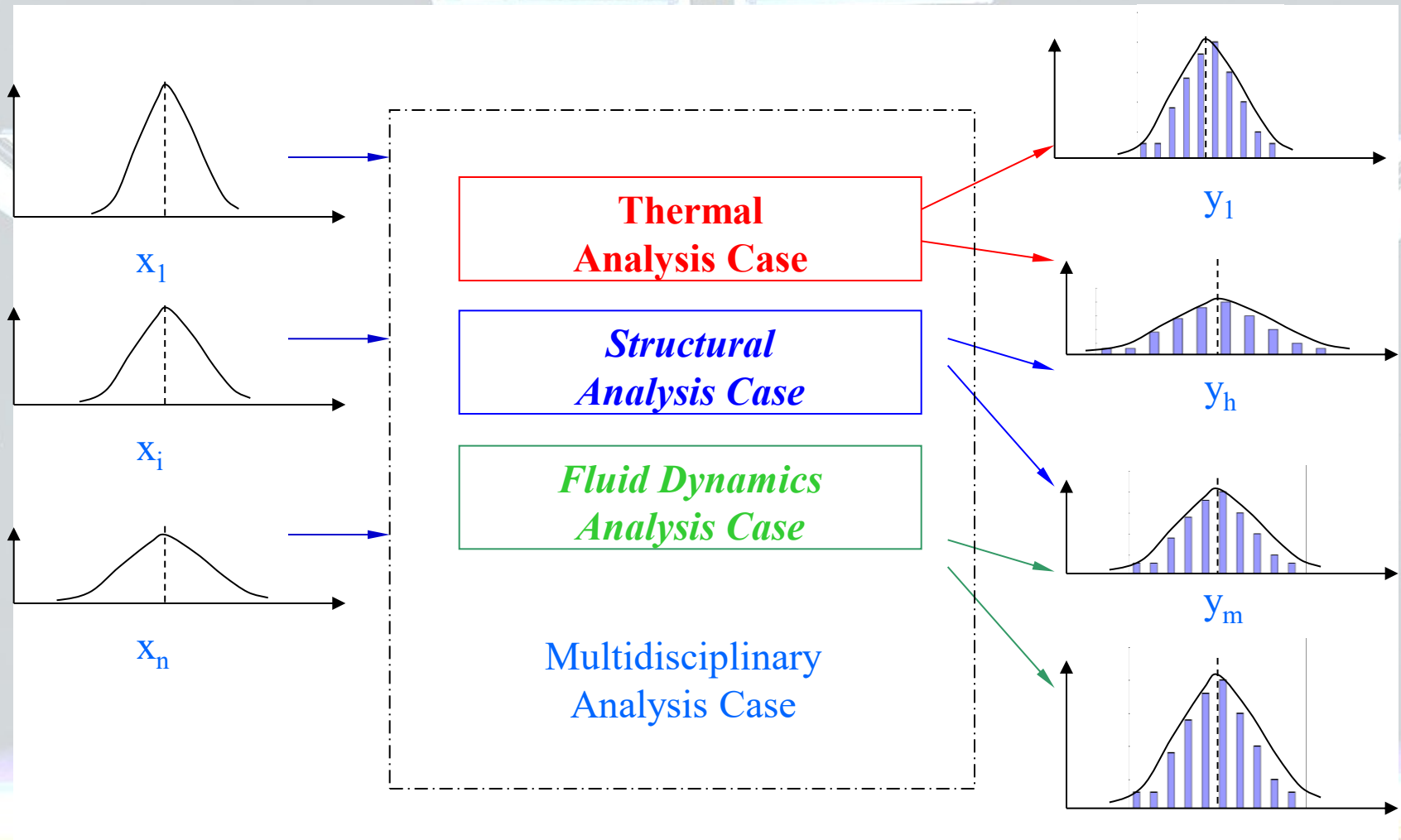
Global Correlation



Local Correlation



MULTIDISCIPLINARY ANALYSIS & DESIGN



INTEGRATED DEVELOPMENT ENVIRONMENT

Model and Analysis Preprocessing

Orbit 3D Viewer

Model Tree Navigator

Model Tree

- S/C
 - box
 - box+Z
 - box-Y
 - box+X
 - box+Y
 - box-X
 - box-Z
 - Baffle
 - Cylinder

Tree Options

Show Surfaces

Geometry Definition

Define Delete

Update DB Reload DB

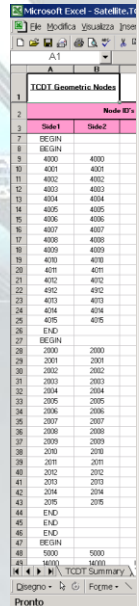
Thermal Network Definition

Update Thermal Model

3D Viewer

Epsilon

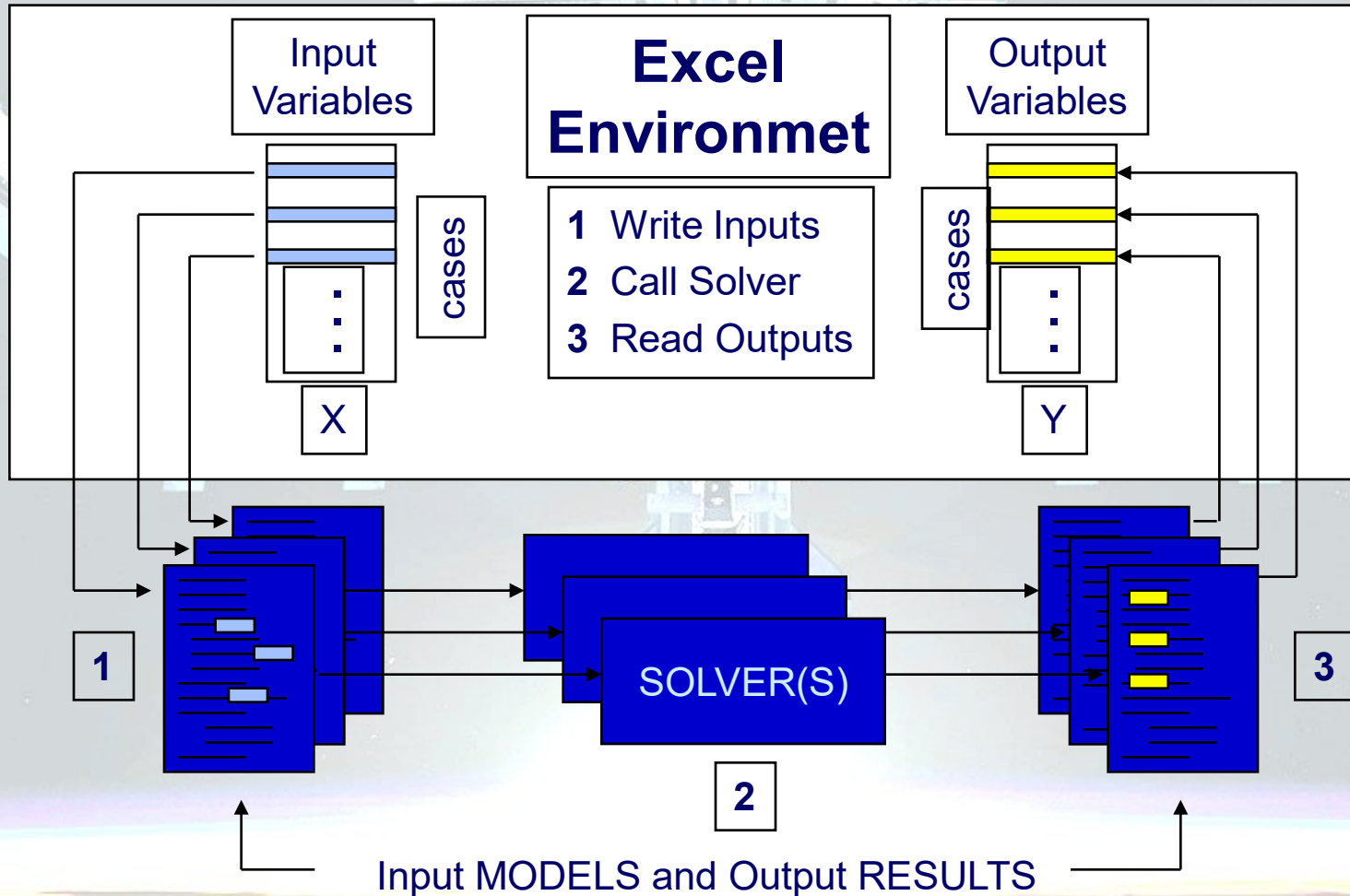
- inactive
- 0.1
- 0.2
- 0.3
- 0.4
- 0.7
- 0.9



TCDT Geometric Nodes	
Node ID	Node ID
7	BEGIN
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40	2012
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42	2014
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INTEGRATED DEVELOPMENT ENVIRONMENT

Parametric Analysis Management

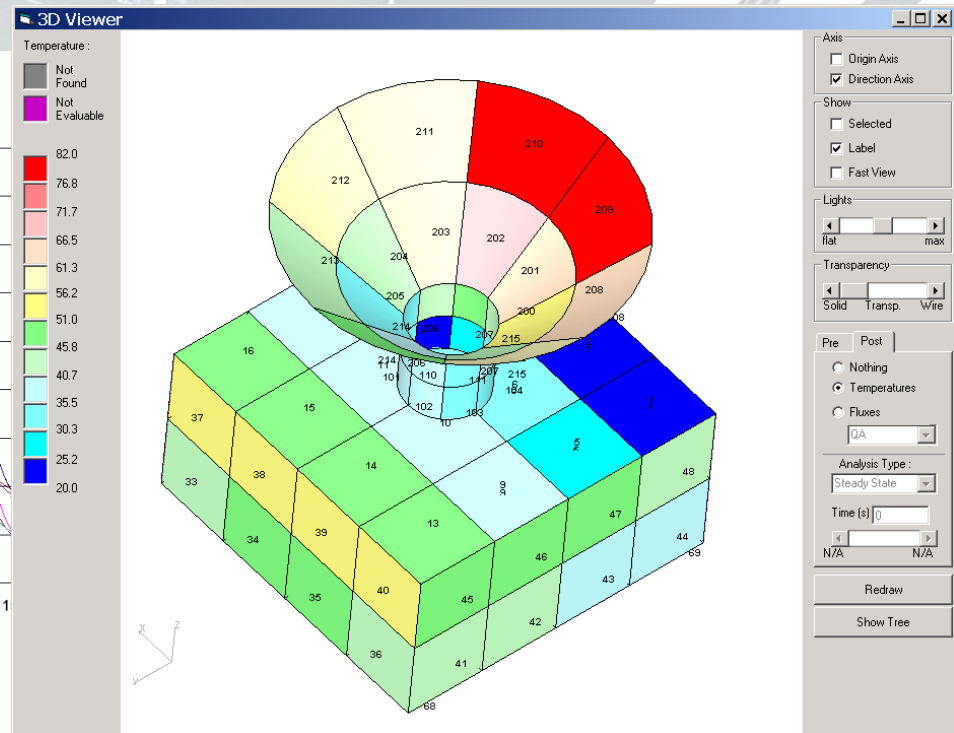
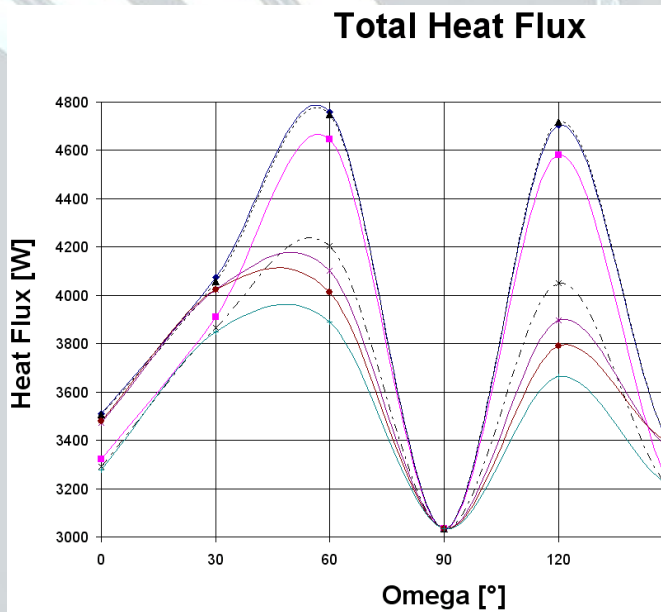


INTEGRATED DEVELOPMENT ENVIRONMENT

Model and Analysis Postprocessing

2D Visualisation

3D Visualisation



PRESENTATION BACKGROUND

TCDT: Thermal Concept Design Tool,
European Space Agency Project 18115/04/NL/CP

FSASTA: Feasibility Of Using A Stochastic Approach For Space Thermal Analysis,
European Space Agency Project 16603/02/NL/CP

TITOSIM: 'Time to Market Reduction via Statistical Information Management',
Growth European project: GRD1 - 2000 – 25724

PROMENVIR: High Performance Computer Based Probabilistic Mechanical Design Environment, ESPRIT European project 20189

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