



SYSTEMA / THERMICA version 4 Overview of the new capabilities

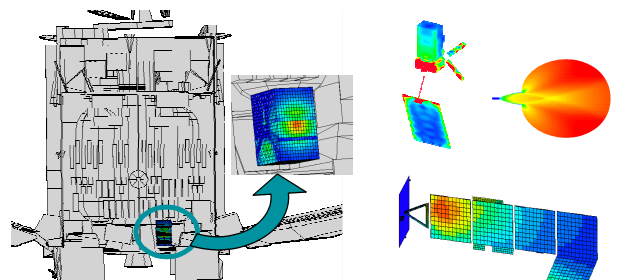
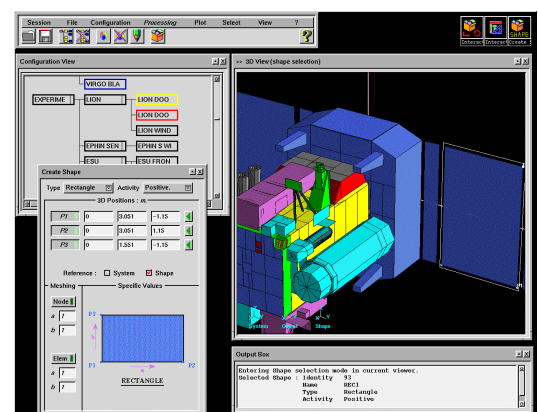
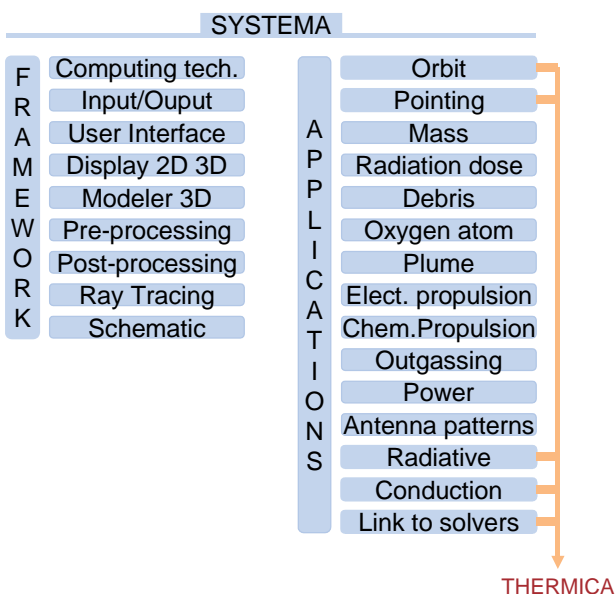


Prepared by Marc Jacquiau, Astrium SAS

16th European Workshop on Thermal and ECLS Software, 22-23 October 2002

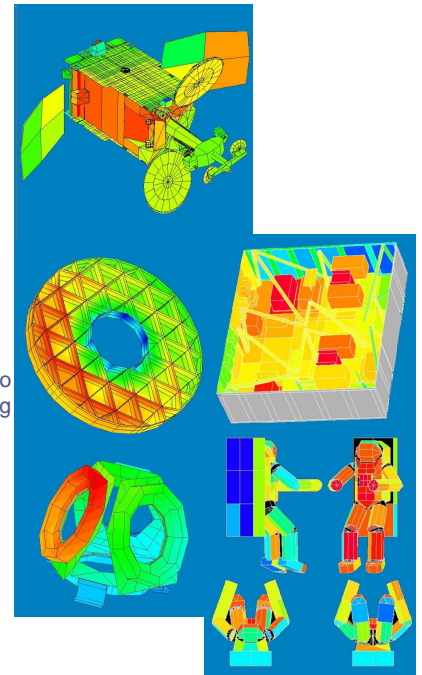
SYSTEMA / THERMICA current status (1/3)

- **SYSTEMA** is a common framework for several spacecraft applications :



SYSTEMA / THERMICA current status (2/3)

- **THERMICA is an integrated thermal chain for the design of spacecraft thermal control :**
 - In feasibility studies
 - For technological choices (passive or active controls)
 - During correlation with test predictions
- **Allows thermal considerations to have an impact on the system design, mission planning and the concept of operations**
- **THERMICA computes :**
 - Thermal radiation exchanges with space and between surfaces
 - External fluxes : Sun, Planet albedo, Planet IR emission
 - Thermal conduction in structures
 - Temperatures by means of other commercial packages (Esatan, Sinda/G)
- **THERMICA takes advantage of common developments with the other applications : framework + mission tools**
 - Reduced cost for users
 - Better synergy for evolutions

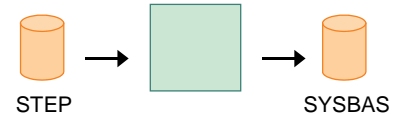


SYSTEMA / THERMICA current status (3/3)

- **Our development philosophy :**
 - To be close to users (internal & external) to fit their needs
 - Users meetings
 - Analysis also performed by software development team
 - To use up-to-date computing technologies : less Fortran, more C/C++, use of OSS
 - To perform enhancements without increasing maintenance cost for users
 - The goal for Astrium isn't to make profit with software but to improve engineering tools
- **User feed-back permits to identify the development priorities**
 - Model generation :
 - Requirement for CAD-like tools
 - Interface with CAD tools
 - Combination of sub-models
 - Thermal model exchange
 - Enhancements for planetary missions
 - Up-to-date user interface : ergonomics, interactivity, link to office tools
- **New capabilities of Thermica version 4**

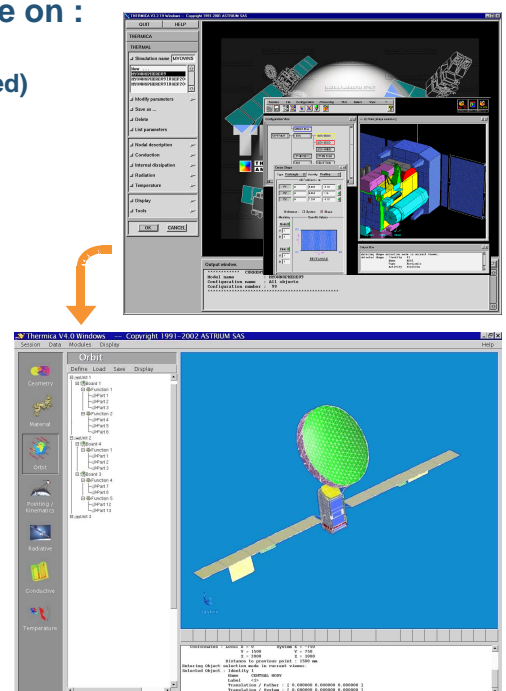
Import of CAD models

- After a survey phase between Astrium and partners, a tool for CAD model import will be developed in 2003
- **Major characteristics :**
 - Use of STEP format
 - Automatic creation of supported shapes
 - Show / No Show capabilities of objects
 - Pick of construction points for shape creation



FRAMEWORK of version 4 : main features

- **New GUI based on Open Source Software, available on : SUN, HP, DEC, SGI, Windows, Linux**
(no need for external GUI packages such as Java or Exceed)
- **Modern look & feel**
based on standard PC tools ergonomy
- **Improvement of interactive 3D graphics**
(fully OpenGL)
- **Better integration into PC office tools**
 - Copy/Paste from Thermica to PC clipboard
→ Insert of figures in Office documents
 - Results available in Excel format
- **Management of submodels**



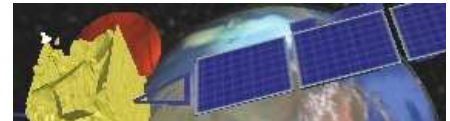
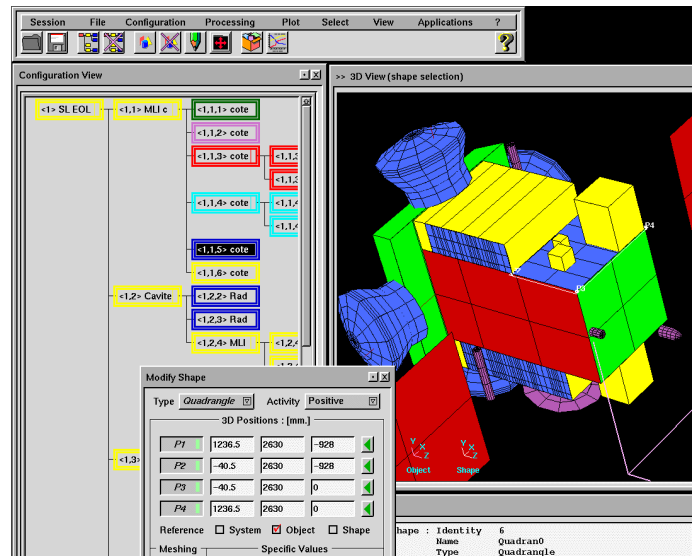
MODELER

- **Current capabilities (v3.2) :**

- Interactive objects/shapes creation
- Interactive pre-post-processing, with animations versus time
- Pick of points/surfaces/objects/nodes and information feed-back
- Interactive motions (\$AXIS)
- Material database management

- **New features :**

- Management of submodels
- Easy use of construction points
- Improvement of interactive motions
- Management of textures for nice displays of coatings
- Management of cutting operations



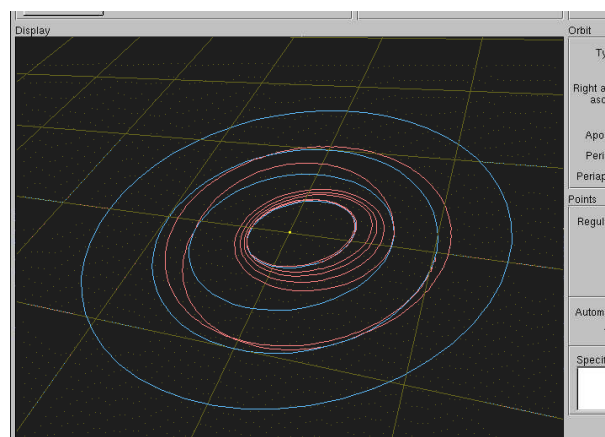
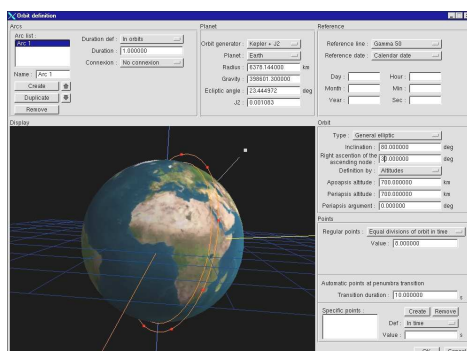
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ORBIT module

- **New Kepler + J2 propagator**
- **Management of orbits around any planet of the solar system**
- **Modelisation of interplanetary missions**
- **New arc connexion by ΔV impulse**
- **Easy import of externally computed orbits (orbit = ASCII file)**
- **Interactive visualisation**



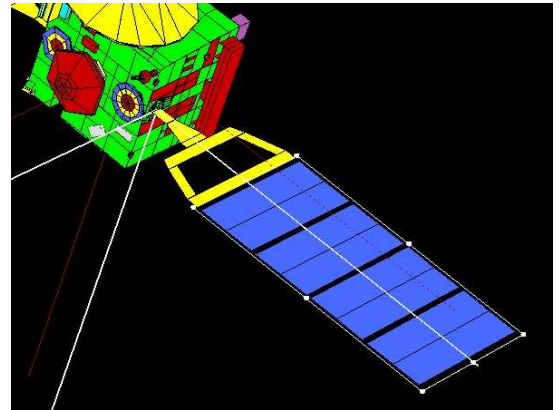
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POINTING module

- Synchronisation with orbital arcs is no more necessary
- In addition to the 14 existing pre-defined pointing directions :
Pointing towards any planet of the solar system...
... from any planet of the solar system
- Easy definition of general kinematic sequences :
 - Translations and rotations given versus time
 - Movement from a given attitude to another in a given time
 - Movement with a given translation & rotation in a given time
- Easy import of externally computed kinematics (kinematics = ASCII file)
- Interactive definition of mobile parts by picking in the 3D view



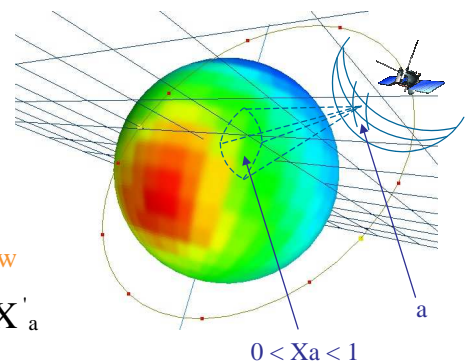
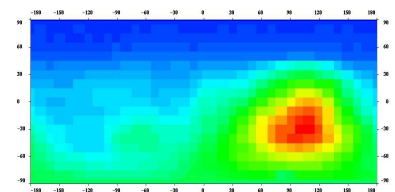
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RADIATIVE module (1/3)

- Planetary albedo and IR fluxes :
 - Ability to take into account user-defined tables giving IR & albedo fluxes versus latitude, longitude and time
 - Useful for scientific missions (still used in Astrium) & LEO satellites with small inertia
 - Interactive display of tables
- Natural enhancement of the existing algorithm :
 - Integration of IR & albedo fluxes evaluated for each solid angle :



$$\Phi_{IR} = \sigma T^4 \sum_a F_{S,a} X_a$$

$$\Phi_a = C_{SUN} \rho_{Planet} \sum_a F_{S,a} X'_a$$

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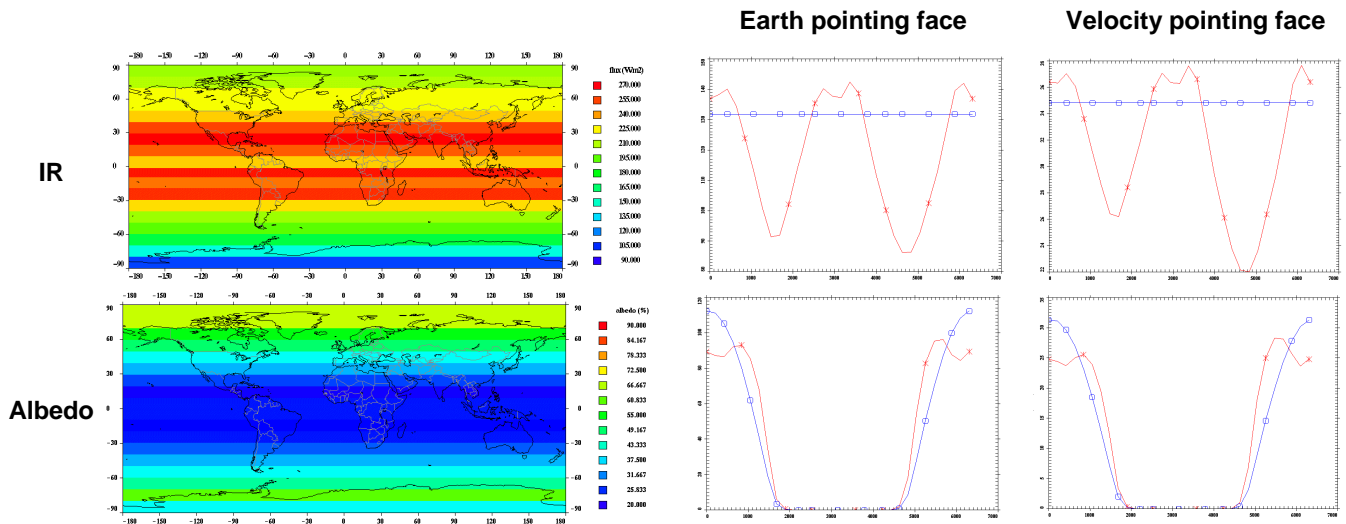
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RADIATIVE module (2/3)

- Comparison with the classical modelisation :**

- Albedo & IR fluxes for a cube ($\alpha=0.4$ $\epsilon=0.75$) on a 1000 km heliosynchronous orbit with a 13.5 H solar time of the ascending node, at spring equinox

(Albedo & IR tables extracted from 'Satellite Thermal Control Handbook', D.G.Gilmore)



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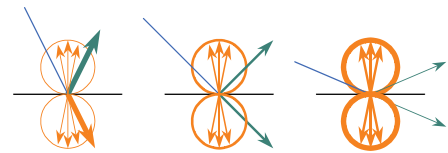
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RADIATIVE module (3/3)

- Improved thermo-optical properties :**

absorption, reflexion and transmission coefficients depending on the light incidence angle (with respect to the surface normal)

- Modelisation of some kind of BRDF
- Tabulated thermo-optical properties
- Properties re-evaluated for each incident ray
- The outgoing direction remains lambertian or specular



- Statistical accuracy control : improvement of large models management**

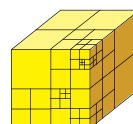
→ how much rays to emit to reach a given accuracy on REFs and fluxes

- Memory management for REF reciprocity law enforcement :**

- no more entire ($n \times n$) matrix in memory (n =number of radiative nodes)
- no more size limit for radiative nodes

- Improved ray tracing : adaptive size of voxels**

- Better memory management
- Faster computations for large models



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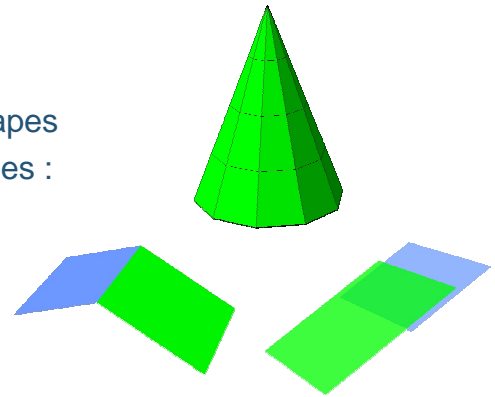
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CONDUCTION module

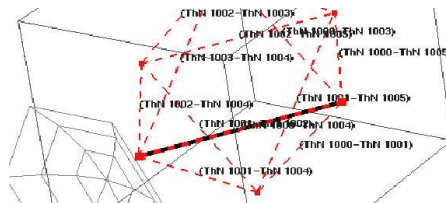
- **Current capabilities (v3.2) :**

- Automatic computation of couplings inside shapes
- Automatic detection of contacts between shapes :
 - Edge contact
 - Surface on top of another surface
- Modelisation of contact resistance



- **New features :**

- Interactive display / selection / definition of couplings in the 3D display



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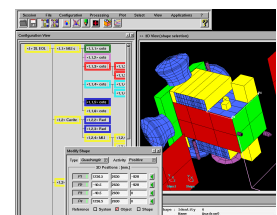
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Development status / availability

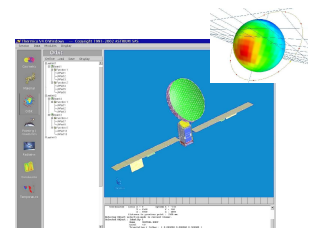
- **Version 3.2.19 : december 2002**

- Statistical accuracy control enhancement
- REF reciprocity law enforcement :
 - no more limit on the nb of radiative nodes
- Availability of the modeler



- **Version 4 : june 2003**

- Orbit / Pointing / Radiative / Conductive modules
 - Batch algorithms performed, validation phase ending
 - User interface + interactive plotting : under development
- Framework, Modeler : still under development



- **Delay due to harmonisation effort :**

- Generic environment for all SYSTEMA modules
- Ability to plug any new module / application in a modern interactive framework

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