Appendix G

THERMICA
On-going research and developments

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Abstract

SYSTEMA: The THERMICA framework
Since the version available last year (4.2.3), the current release offers new functionalities:

- New framework based on QT technology
- Boolean Shapes
- Multi-kinematics and sequences management
- Video recording

+ Presentation of some on-going developments for the next release.

THERMICA 4.3.1

- Extended for the new SYSTEMA functionalities
- Integrate maps for planet properties and/or night/day temperatures definition for the IR flux
- Integrate the new conductive method: the RCN

  The Reduced Conductive Network is a new method compatible with the radiative mesh and can also be used for better convergence finite elements methods as well.
  The main idea of the RCN method is to determine a sub-space of linearly equivalent results and to find a particular solution from this sub-space. This solution provides some particular properties which make it compatible with radiative aspects and is given by the limit of a specific function.

+ Presentation of some on-going developments for the next release.

THERMICA

V4.3.1 Presentation
On-Going Researches & Developments
Demonstration

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SYSTEMA / THERMICA - Versions

- V 4.2.3
  - July 2007

  Presented last year at the 2007 ECLS Workshop

- V 4.3.0
  - March 2008

  Current release

- V 4.3.1
  - November 2008

  Next release

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SYSTEMA v4.3.1 / 4.2.3

- Framework based on QT technology
  - **Intuitive**, **User Friendly** and **Ergonomic**
- Boolean shapes
  - Cutting operations **flexible** and **easy to handle**
- Multi-kinematics and sequences management
  - Helps creating **complex mission scenarios**
- Video recording for multimedia presentation
  - **Realistic rendering** with textures and display properties
  - **Smart camera** following satellites or planets

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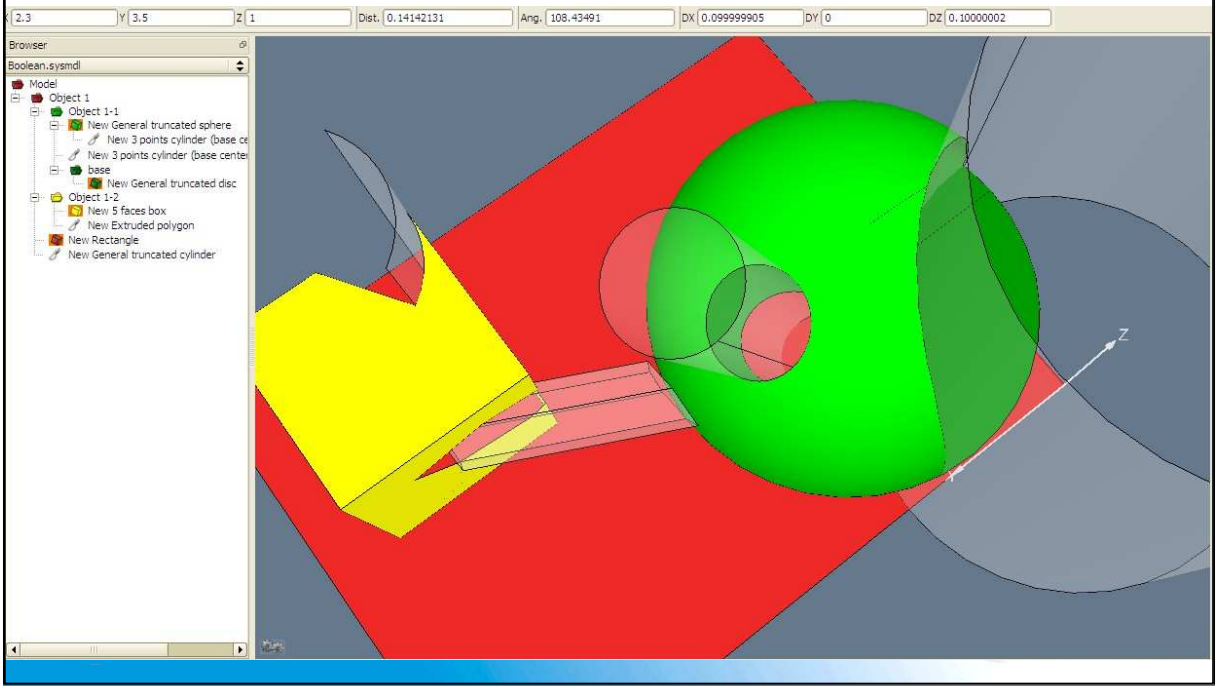
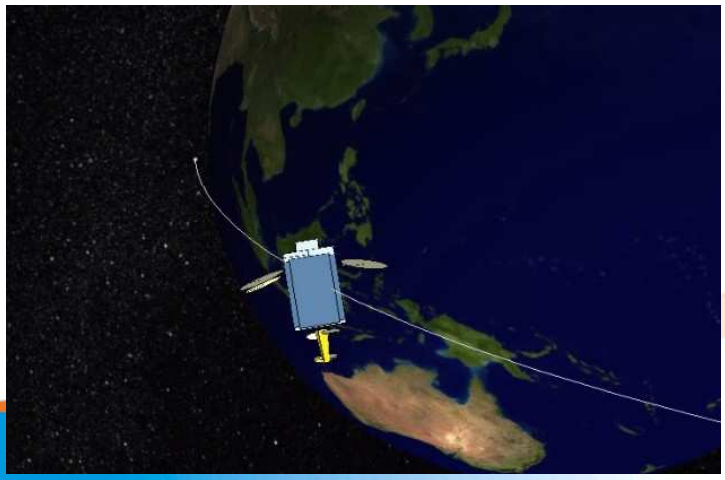
Boolean shapes

- Demonstration



Multi-kinematics & Sequence Management

- Video from SYSTEMA
  - Injection of a Telecommunication Satellite with Solar Panels deployment



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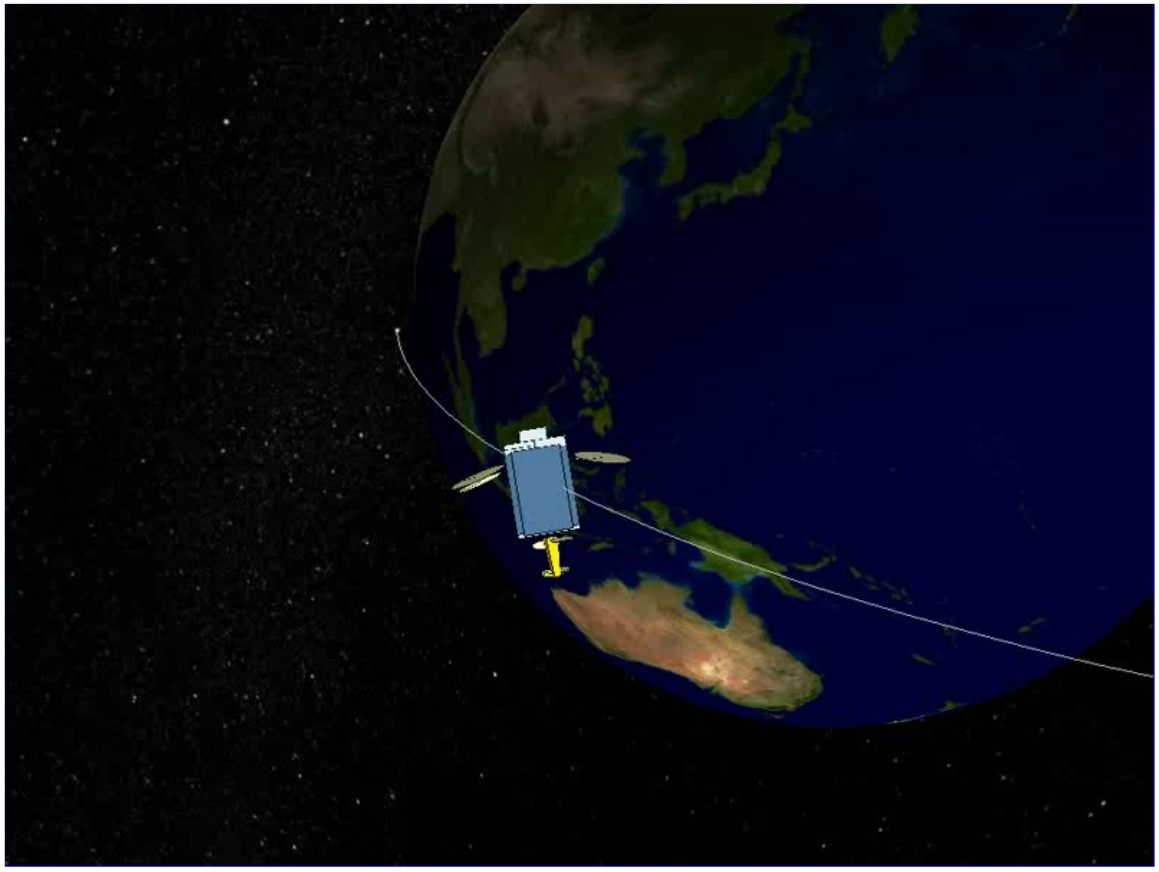
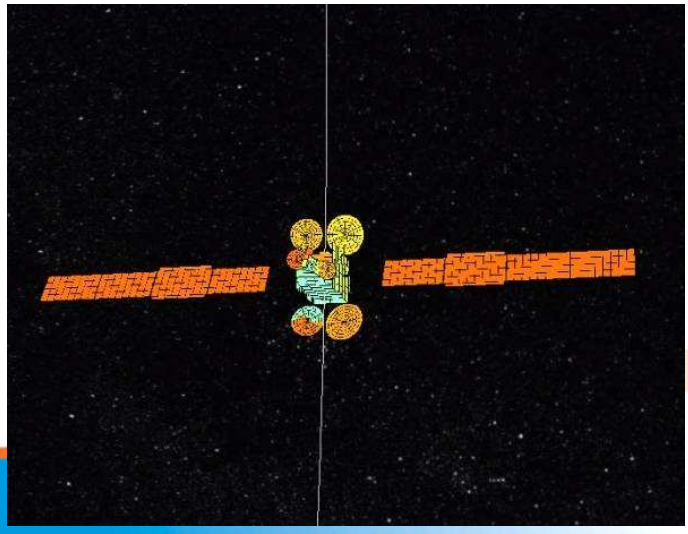


If clicking on the picture above does not run the movie then try opening the file 'movies/Telecom-Injection-Deployment-1mn.html' manually.

Multi-kinematics & Sequence Management

- Video from SYSTEMA
  - Results of Solar Fluxes on a Telecommunication Satellite



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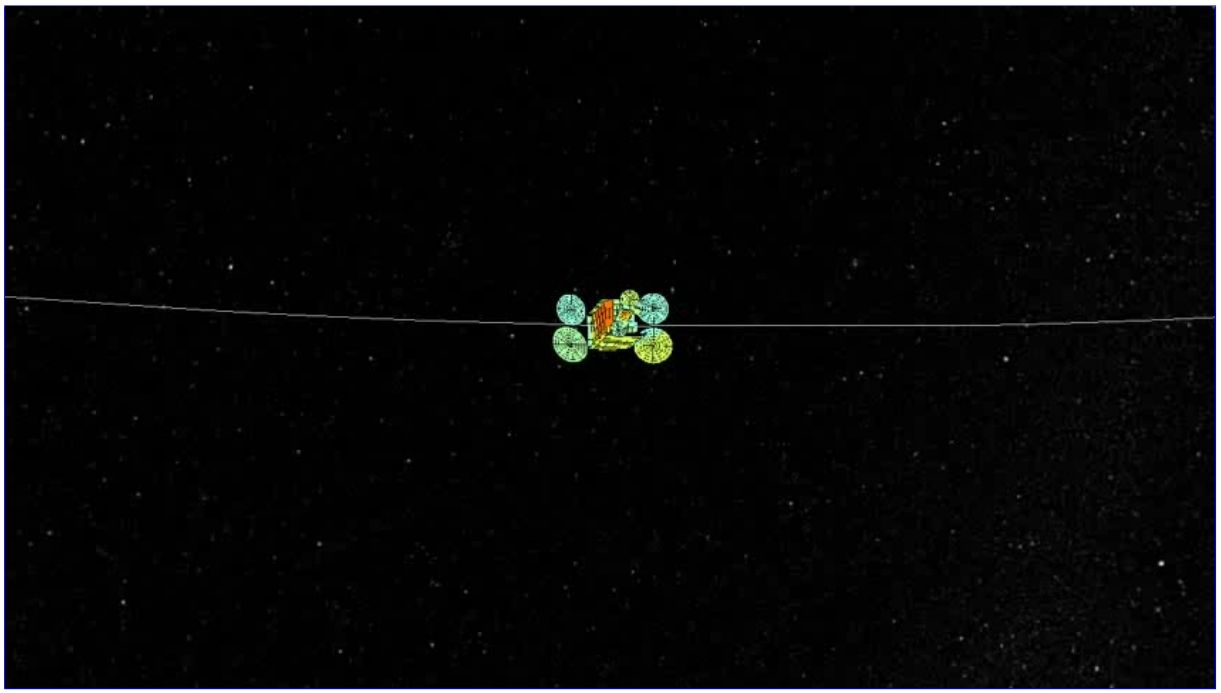
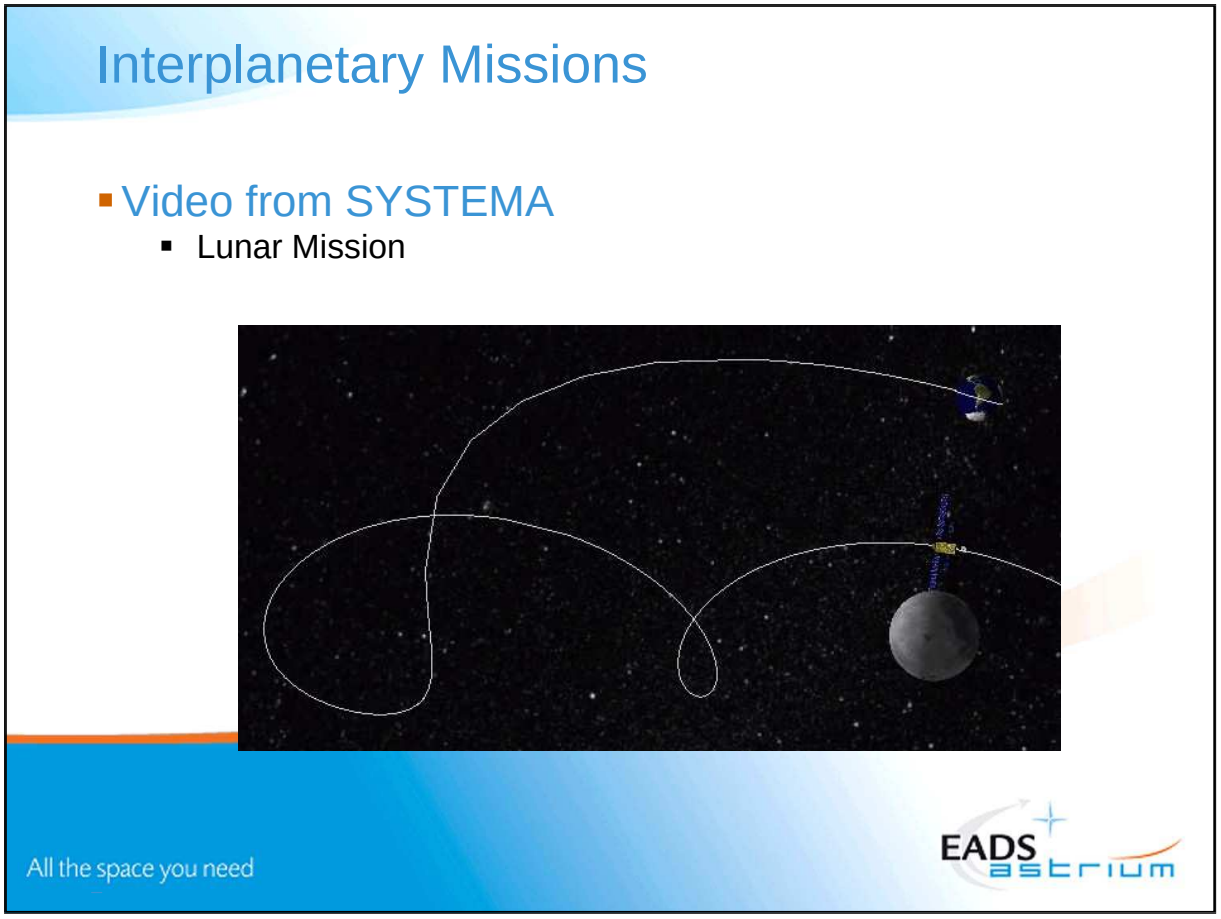
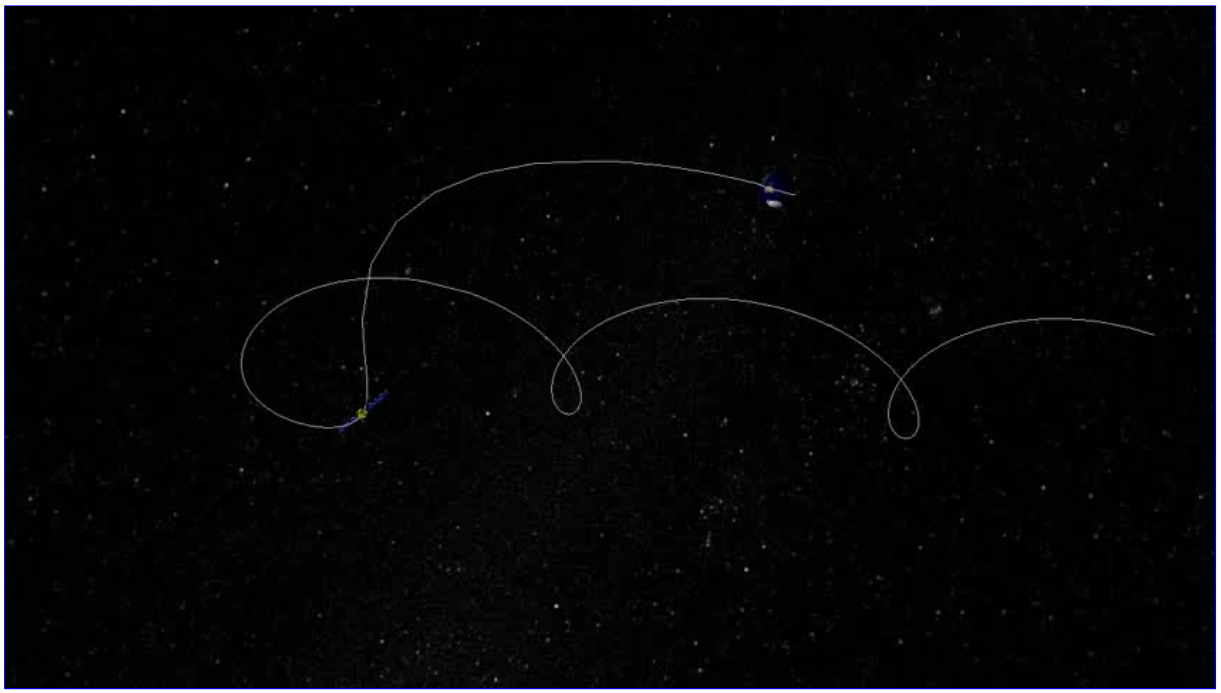


If clicking on the picture above does not run the movie then try opening the file ‘movies/Telecom-DirectSolarFlux-3mn.html’ manually.





If clicking on the picture above does not run the movie then try opening the file ‘movies/Solo-large.html’ manually.

SYSTEMA - future evolutions

- Improvement of the 3D and ergonomics
  - Significant 3D improvements
  - New icon bars and ergonomic features
- Time-line management
  - Easy management of mission scenario
  - Management of events
- Step-Tas import/export

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THERMICA v4.3.1 / 4.2.3

- Integrate all the new SYSTEMA functionalities
  - Handle **boolean shapes** in radiative analysis
  - Handle **complex mission scenario**
- Complex planet environment
  - Possibility to define **maps** of properties for **any planet**
  - Easy specification of **night/day** planet **temperatures**
- Conductive analysis
  - First development of the **RCN method**

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Conductive analyses: the RCN method

- The ***Reduced Conductive Network*** method
  - Compatible with **Radiative Mesh**
  - Compatible with **not conformant meshes**
  - Compatible with **boolean shapes** *(not implemented in v4.3.1)*
  - **Integrates** the fluxes on the edges

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Conductive analyses: the RCN method

- Principle of the RCN approach
  - It defines a sub-space of linearly exact results
  - It searches within this sub-space a particular solution for which
    - The nodes (edges/surface) correspond to **mean temperatures** (and not geometrically localized temperatures)
    - The couplings **do not depend on a temperature profile**

The RCN solution can be reached analytically or by a process integrating the fluxes on the edges
(to deal with not conformant meshes and boolean shapes)

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New Mapping Module

- Based on the RCN method
  - Load of **FEM model**
    & **Visualization** of both Thermal/FEM model
  - Definition of **associations** *(optional)*
  - **Mapping** of temperature results
    based on a **detailed** recalculated **temperature profile**
    (thanks to a backward RCN approach)
  - **Export** of the temperatures on the mechanical mesh

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On-going researches on Radiative Analyses

- Needs for a new method for Radiative Analyses
  - To get **more accuracy** and **faster**
  - To deal **more efficiently** with **larger model**
- Main idea of the new method

  Re-use of some information of the classical ray-tracing algorithm in order **to increase the accuracy** of the Radiative Exchange Factors and **to optimize the ray-tracing** process itself

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New Radiative Analyses Method

- Actual status
  - **Fundamental aspects** have been mathematically **consolidated**
  - Major **algorithms aspects** have been **implemented**
  - Tests are being made to

    - Validate the method
    - Optimize it (accuracy and performances)

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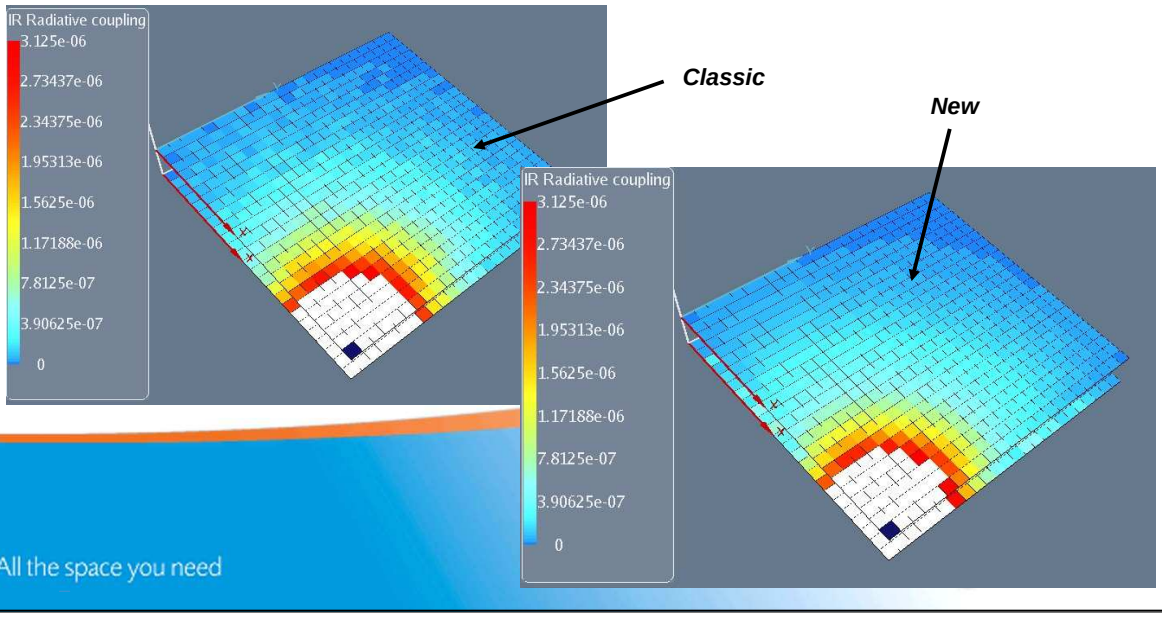
New Radiative Analyses Method

- Preliminary results
  - Test of 2 plane surfaces seeing one each other



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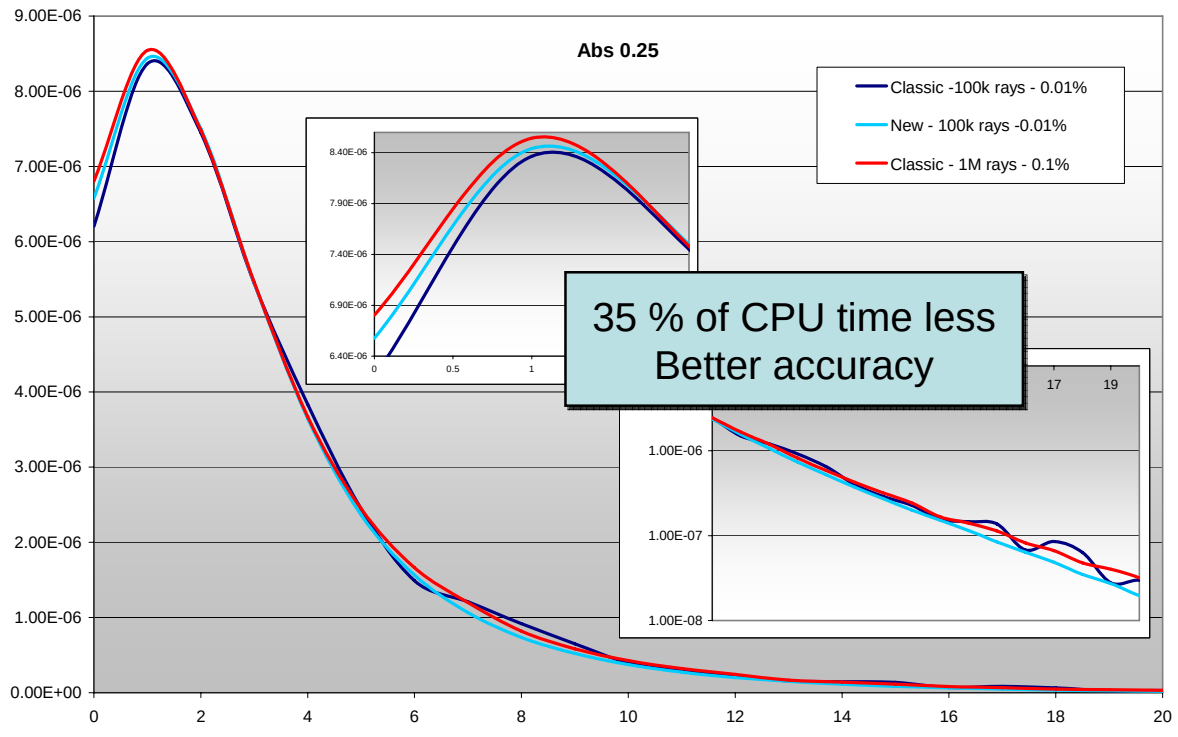
New Radiative Analyses Method



New Radiative Analyses Method

- Preliminary conclusions
  - The method seems to **converge correctly** to the exact results
  - The **gain of CPU time** is significant when a good accuracy is required
- Further developments
  - Many other tests are necessary to confirm the expectations of the method and to consolidate its implementation
  - Final integration to the Radiative and Solar fluxes analyses to be done

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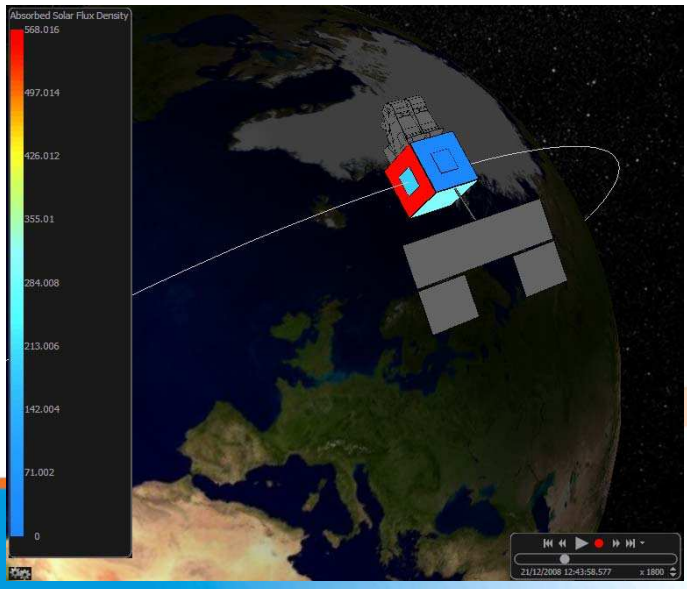
THERMICA v4.3.1 - Demonstration

- Spot : Radiative and Fluxes Analysis



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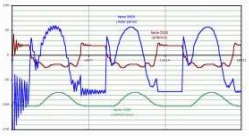
THERMISOL - Applications

THERMISOL has been used, validated and optimized on many projects. Thanks to 5 years of intense use in Astrium, convergence optimizations were finely tunes. Here are examples of the **THERMISOL** special features.

Automatic time-step adjustment

SCRANKAUTO provides an automatic time-step based on minimum and maximum error specifications.

During the computation, the error is estimated by the Taylor development and the time-step is automatically changed so the solution stays in the given accuracy range.



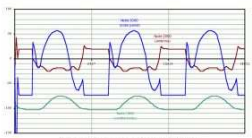
Automatic time-step adjustment

Here is an example of a solution computed by the classical SLFWBK routine. The solution plotted hereafter shows the evolution of temperature for 3 nodes : 1000 (central body), 2000 (antenna), and 3000 (solar panel).

The oscillations can be drastically reduced by the use of an automatic time stepping. In the previous input file, the call to SLFWBK has been replaced by a call to the subroutine SCRANKAUTO, and two control variables have been added in the paragraph $CONTROLS :

```
ERRMIN = 0.01; ERRMAX = 0.01;
```

The new solution is plotted in the following graph :



Automatic time-step adjustment

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