Appendix I

SYSTEMA 4.3.4

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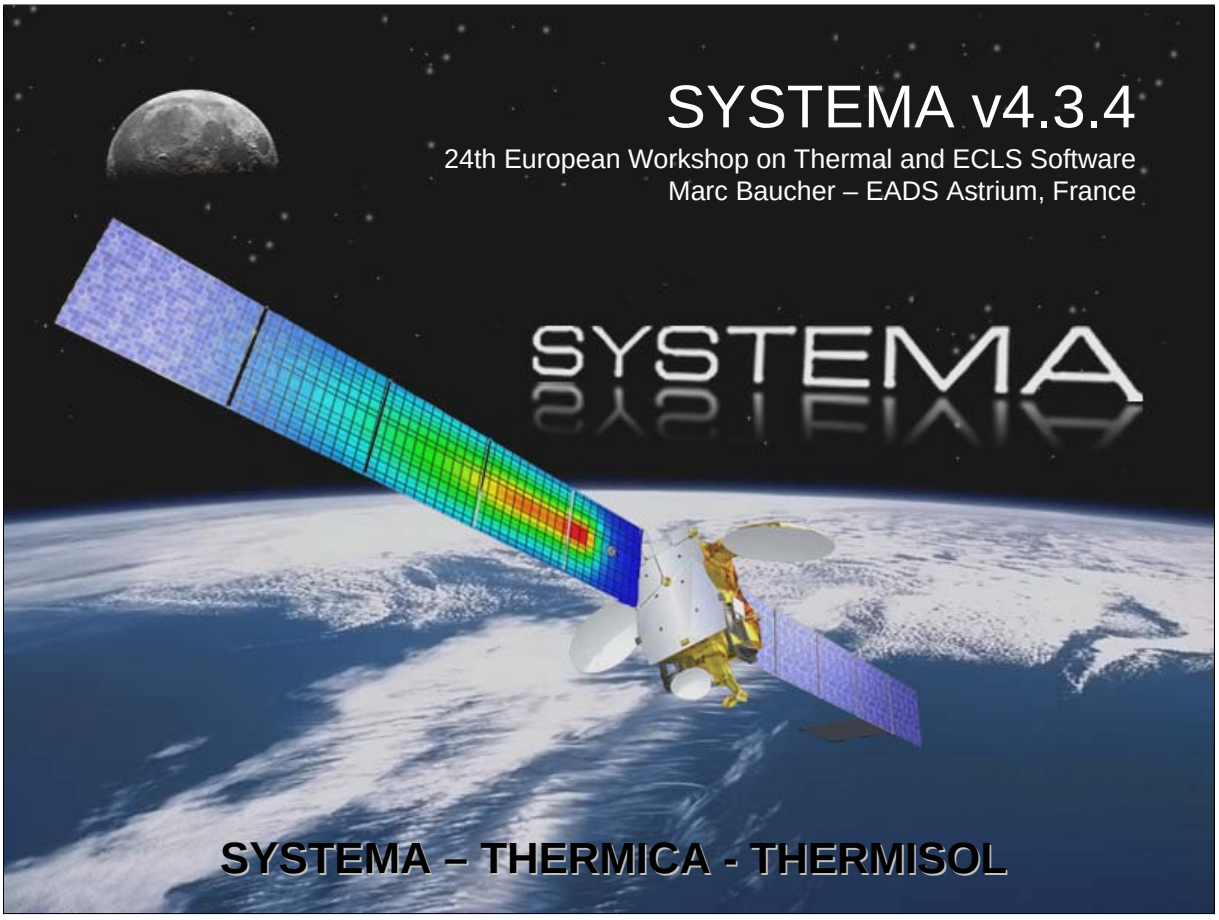
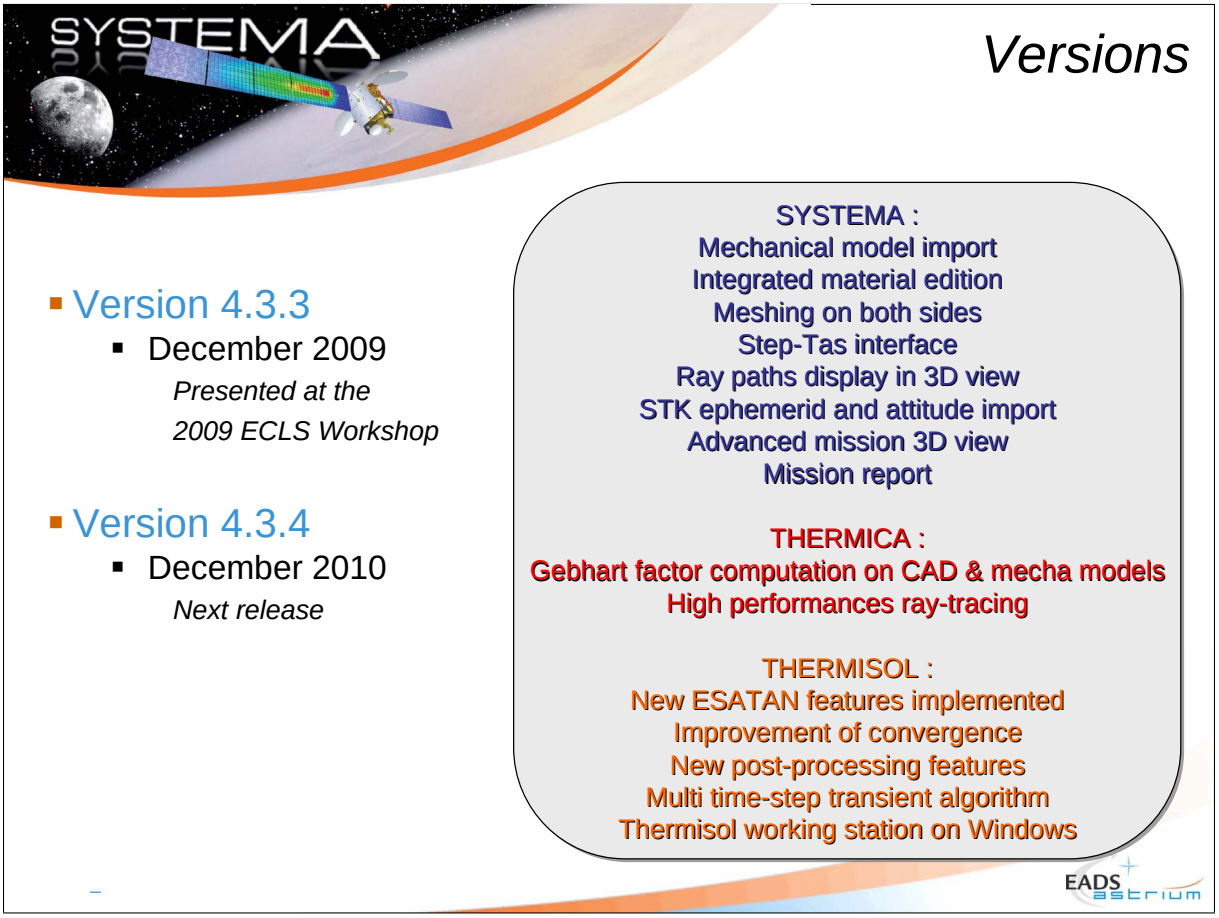
Abstract

Thermal computation on mechanical and CAD models
SYSTEMA 4.3.4 introduces even more flexibility in geometrical modeling. Mechanical or CAD models can be imported from NASTRAN or I-DEAS (BLK BDF), CATIA (Step AP-203) or other tools (VRML). The THERMICA/THERMISOL tool chain can then be executed on these models without any shape modification or with partial modifications (for example to suppress some details, simplify some elements or create analytical shapes to replace discretized curved geometries).
Furthermore, SYSTEMA offers a large panel of intuitive tools to simplify geometry and easily assemble, compare and modify mechanical and thermal models. The version 4.3.4 now also allows saving within the model all the help items such as grids, lines or points which have been used to interactively create shapes).

STEP-TAS interface
For the last two years, we have been working with ESA and CSTB to get a complete STEP-TAS interface. It is now possible to directly import from SYSTEMA this format which will be converted to a v4 model, meshing and material databases.
Thanks to the v4 upgrades, this conversion is compliant with most of the STEP-TAS features. Boolean cuts are handled for prism and cylinder truncations and will also include the cutting plane next year. Distinct sides numbering are also available from version 4.3.4. The list of restrictions between the STEP-TAS capabilities and the SYTEMA ones have then been decreased to only a few elements such as the cutting plane, grid spacing (but they will both be implemented next year) and the sub-grid.
This import/export options have already been successfully tested on many cases, including industrial ones from the IITAS test plan but also additional cases.
This interface can already be activated in version 4.3.3 and will be fully available in version 4.3.4.

Wide Mission simulation
SYSTEMA v4 has been developed with the concern of managing the complete solar system in order to simulate any mission. The localization of all planets is known with an accuracy of a hundred kilometers at any time. In addition, rotational frames of the Earth, the Moon and other planets are also available and allow the definition of landed missions.
The mission viewers have been extended with predefined camera positions (from/to the Sun, Velocity, a planet ...) and the possibility to represent the kinematics frames animated with the spacecraft. This realistic rendering is particularly helpful to understand the behavior of the implemented mission, especially when complex kinematics have been used. In addition to the analytical definition, it is now possible to study specific configurations thanks to 2 new options. The "Fix Sun" option can be used to freeze the relative movement of the planets and Sun to their positions at the beginning of the simulation. Also a "search" function is available to find the next date of a given Sun declination.


SYSTEMA v4.3.4
24th European Workshop on Thermal and ECLS Software
Marc Baucher – EADS Astrium, France
SYSTEMA
SYSTEMA – THERMICA - THERMISOL


SYSTEMA
Versions
Version 4.3.3
December 2009
Presented at the
2009 ECLS Workshop
Version 4.3.4
December 2010
Next release
SYSTEMA :
Mechanical model import
Integrated material edition
Meshing on both sides
Step-Tas interface
Ray paths display in 3D view
STK ephemerid and attitude import
Advanced mission 3D view
Mission report
THERMICA :
Gebhart factor computation on CAD & mecha models
High performances ray-tracing
THERMISOL :
New ESATAN features implemented
Improvement of convergence
New post-processing features
Multi time-step transient algorithm
Thermisol working station on Windows
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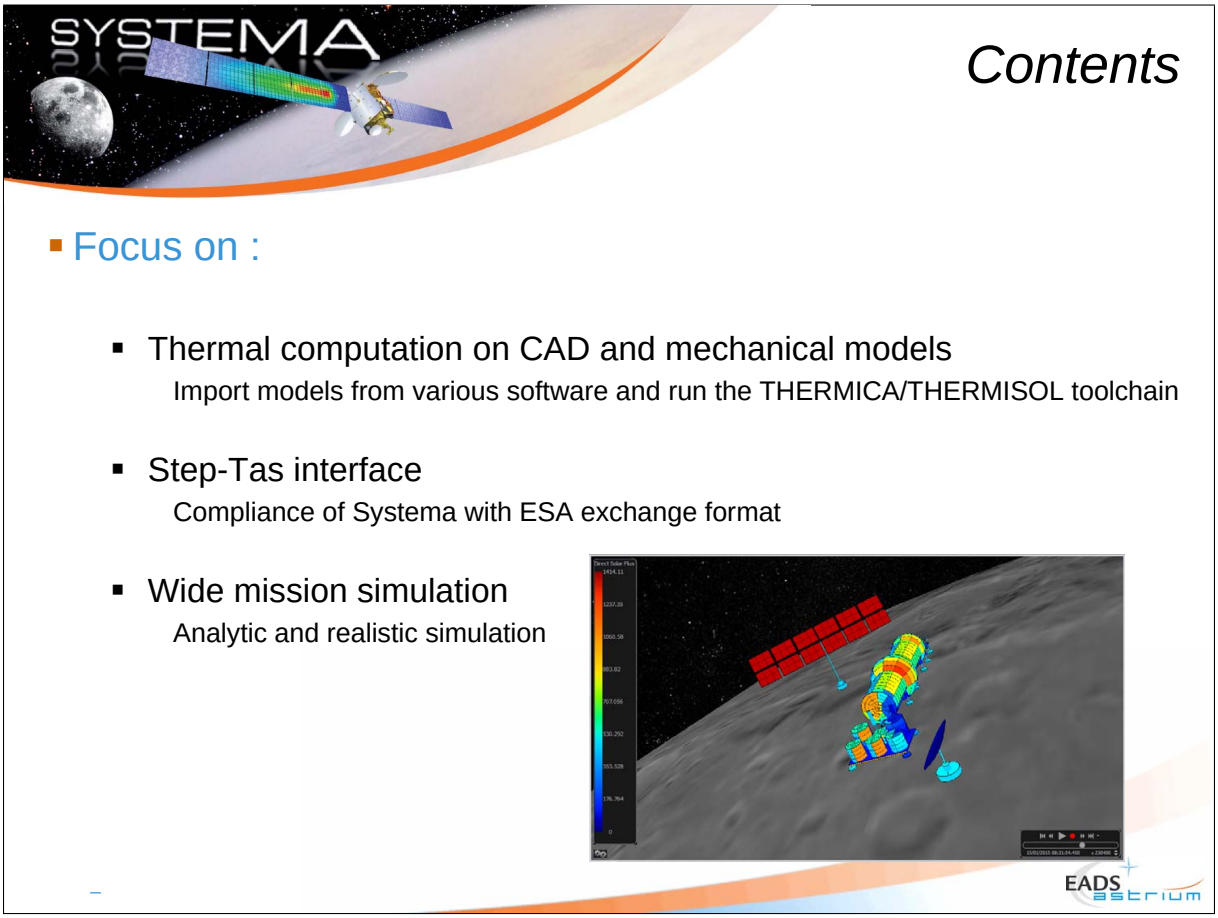
SYSTEMA
Contents
Focus on :
Thermal computation on CAD and mechanical models
Import models from various software and run the THERMICA/THERMISOL toolchain
Step-Tas interface
Compliance of Systema with ESA exchange format
Wide mission simulation
Analytic and realistic simulation
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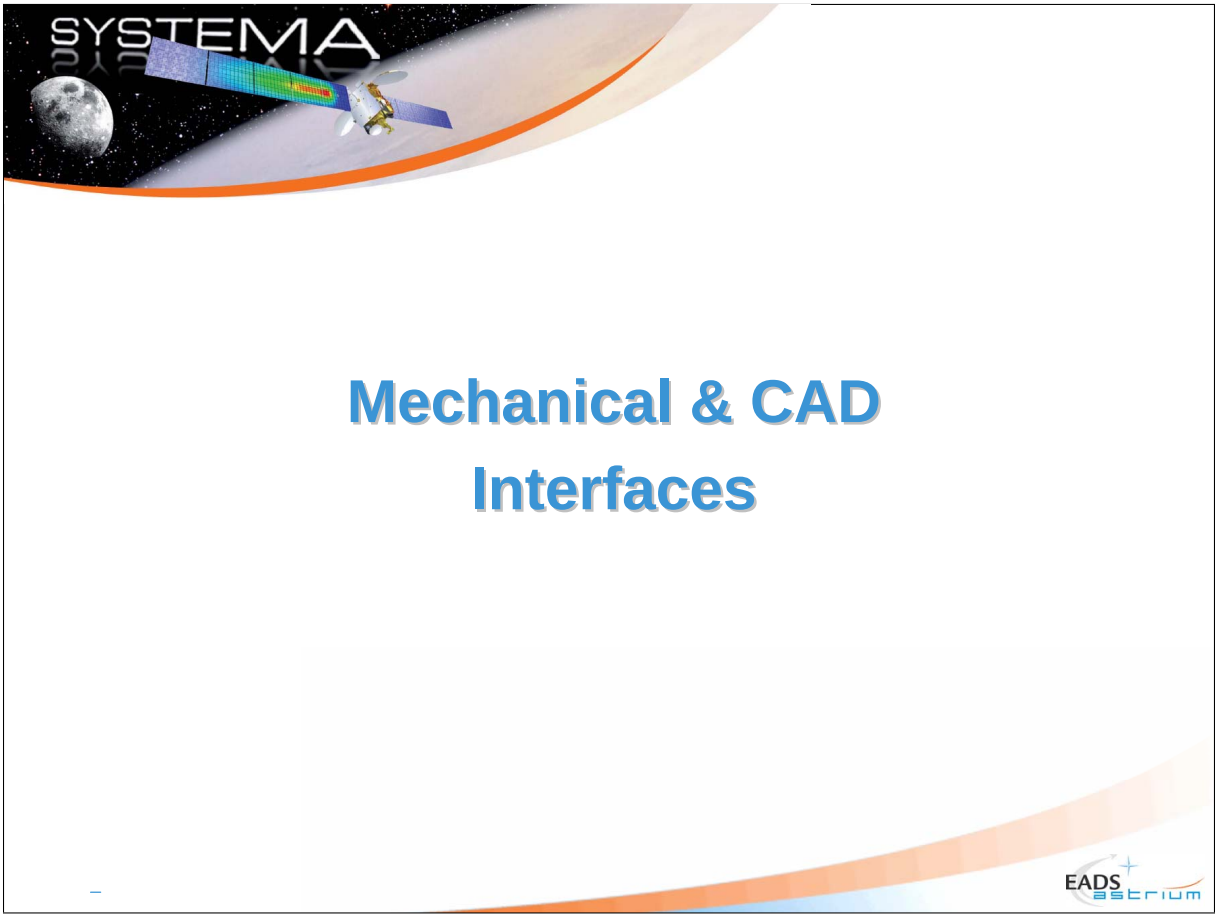
SYSTEMA
Mechanical & CAD Interfaces
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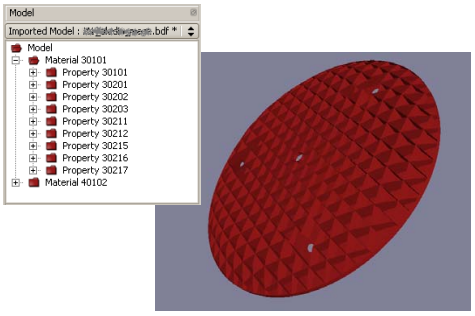
CAD & mechanical models

- SYSTEMA is compatible with :
  - I-Deas & Nastran
    BDF (BLK) : geometry organized by MID & PID with mechanical identifier
  - Catia models
    Step AP203 : geometry in a tree structure
  - Other tools
    VRML v2 : geometry

CAD & mechanical models

I-Deas & Nastran BLK interface

- Importing features
  - Imported shapes are ready to work
    - Triangles & quadrangles
    - Coordinate systems taken in account
  - Items are organized
    - Shapes are sorted by mechanical material and property (MID/PID)
    - Mechanical numbering is imported
  - SYSTEMA manages complete mechanical models
    - High detailed models can be imported

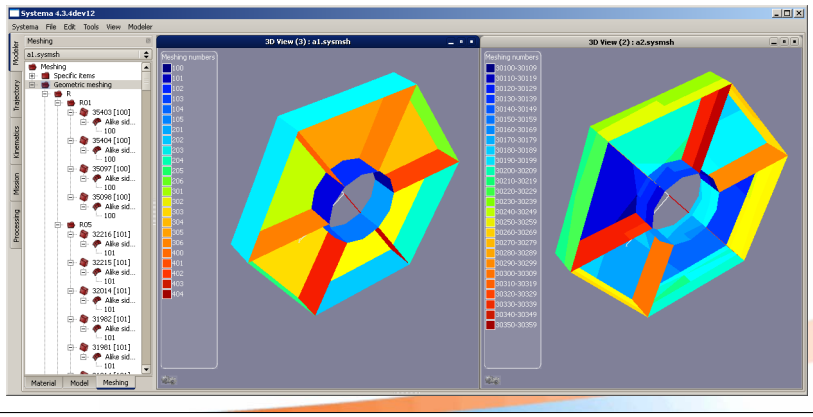


SYSTEMA

CAD & mechanical models

I-Deas & Nastran BLK interface

- Numbering
  - Building the thermal numbering from the mechanical numbering
    - Thanks to the sorting by MID & PID, shapes are grouped by components
    - Nodes can be quickly condensed or gathered in sub-models
    - Numbering comparison : thermal and mechanical meshing on the same geometry



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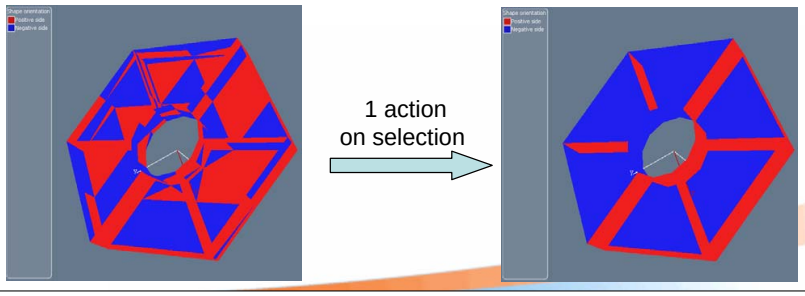
SYSTEMA

CAD & mechanical models

I-Deas & Nastran BLK interface

- Thermal properties
  - Material
    - Thermal materials can be easily assigned to all the shapes, thanks to inheritance properties and the built hierarchy based on MID and PID
  - Shapes orientation management
    - SYSTEMA allows to visualize shape orientation
    - By one action, reverse the orientation of selected shapes



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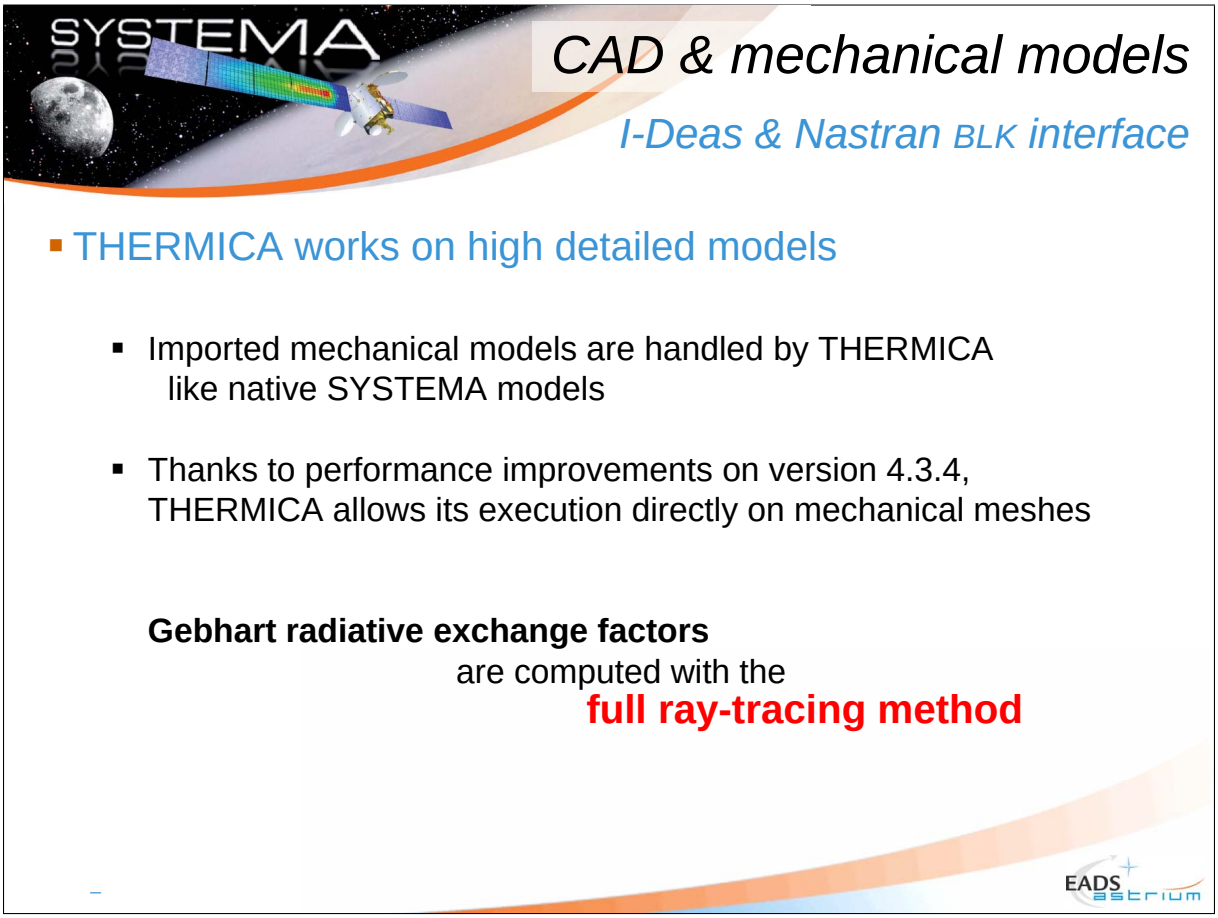
SYSTEMA
CAD & mechanical models
I-Deas & Nastran BLK interface
THERMICA works on high detailed models
Imported mechanical models are handled by THERMICA like native SYSTEMA models
Thanks to performance improvements on version 4.3.4, THERMICA allows its execution directly on mechanical meshes
Gebhart radiative exchange factors
are computed with the
full ray-tracing method
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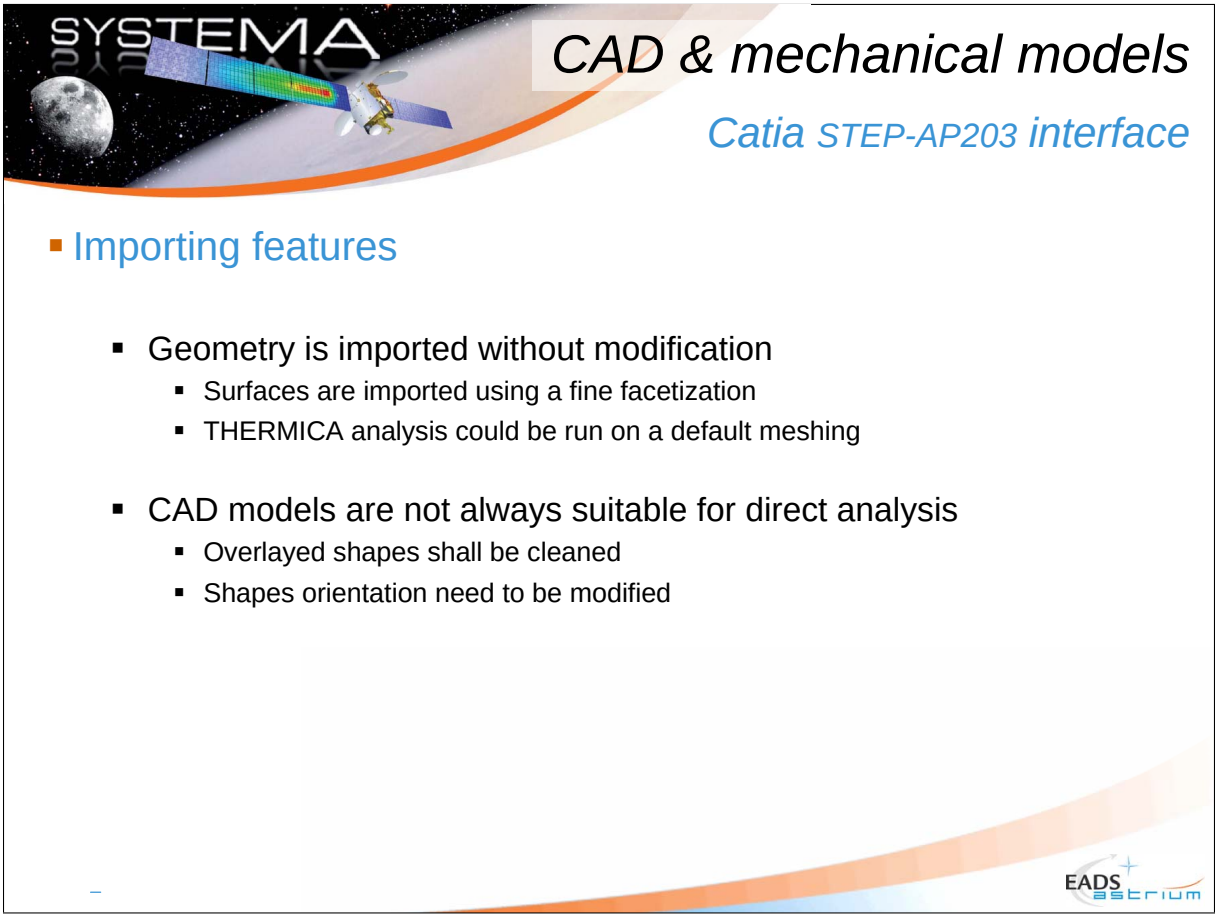
SYSTEMA
CAD & mechanical models
Catia STEP-AP203 interface
Importing features
Geometry is imported without modification
Surfaces are imported using a fine facetization
THERMICA analysis could be run on a default meshing
CAD models are not always suitable for direct analysis
Overlayed shapes shall be cleaned
Shapes orientation need to be modified
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SYSTEMA

CAD & mechanical models

Catia STEP-AP203 interface

- Geometry modifications
  - Volumes with small thickness are modelled where it would be preferred to use a plane surface
    - Shape orientation shall be reversed to be homogeneous
    - Activity shall be turned off in the inner
  - Two ways to deal with detailed geometry
    - Geometry can be used as it (with possible condensation)
    - Otherwise, SYSTEMA offers advanced tools to simplify the model

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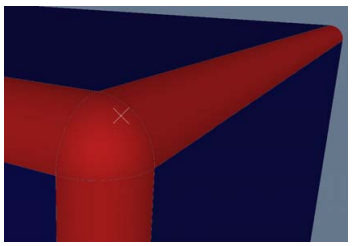
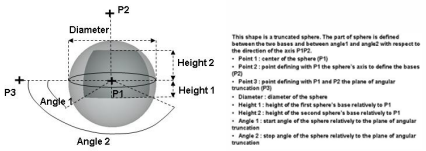
SYSTEMA

CAD & mechanical models

Catia STEP-AP203 interface

- Geometry simplification
  - Help items
    - Points, lines and planes creation
      - Middle, curve and sphere centers
      - Intersection line / plane and line / line
    - Help items are stored with the model
  - Large choice of shapes definition
    - +60 shape types : interactive and static creation
    - Contextual documentation





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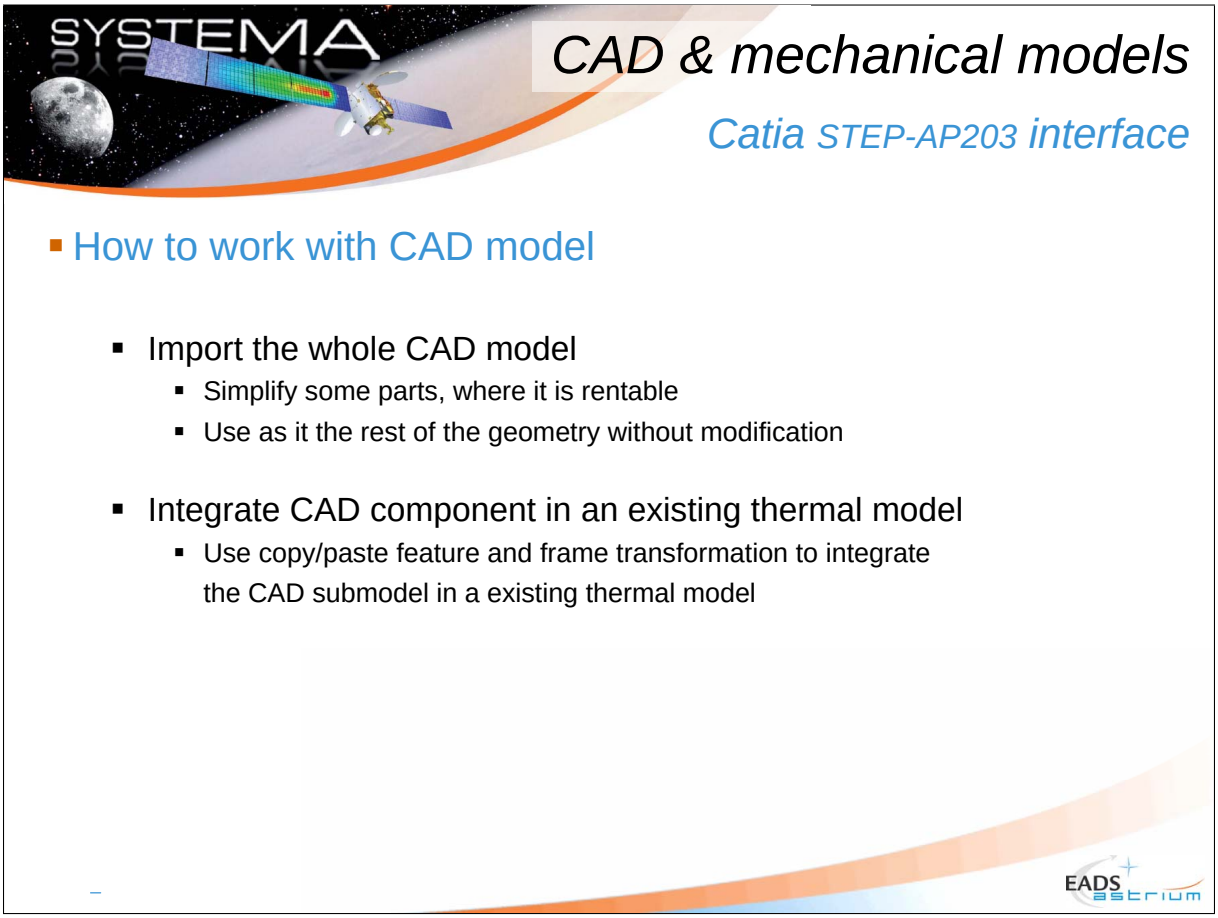
SYSTEMA
CAD & mechanical models
Catia STEP-AP203 interface
How to work with CAD model
Import the whole CAD model
Simplify some parts, where it is rentable
Use as it the rest of the geometry without modification
Integrate CAD component in an existing thermal model
Use copy/paste feature and frame transformation to integrate the CAD submodel in a existing thermal model
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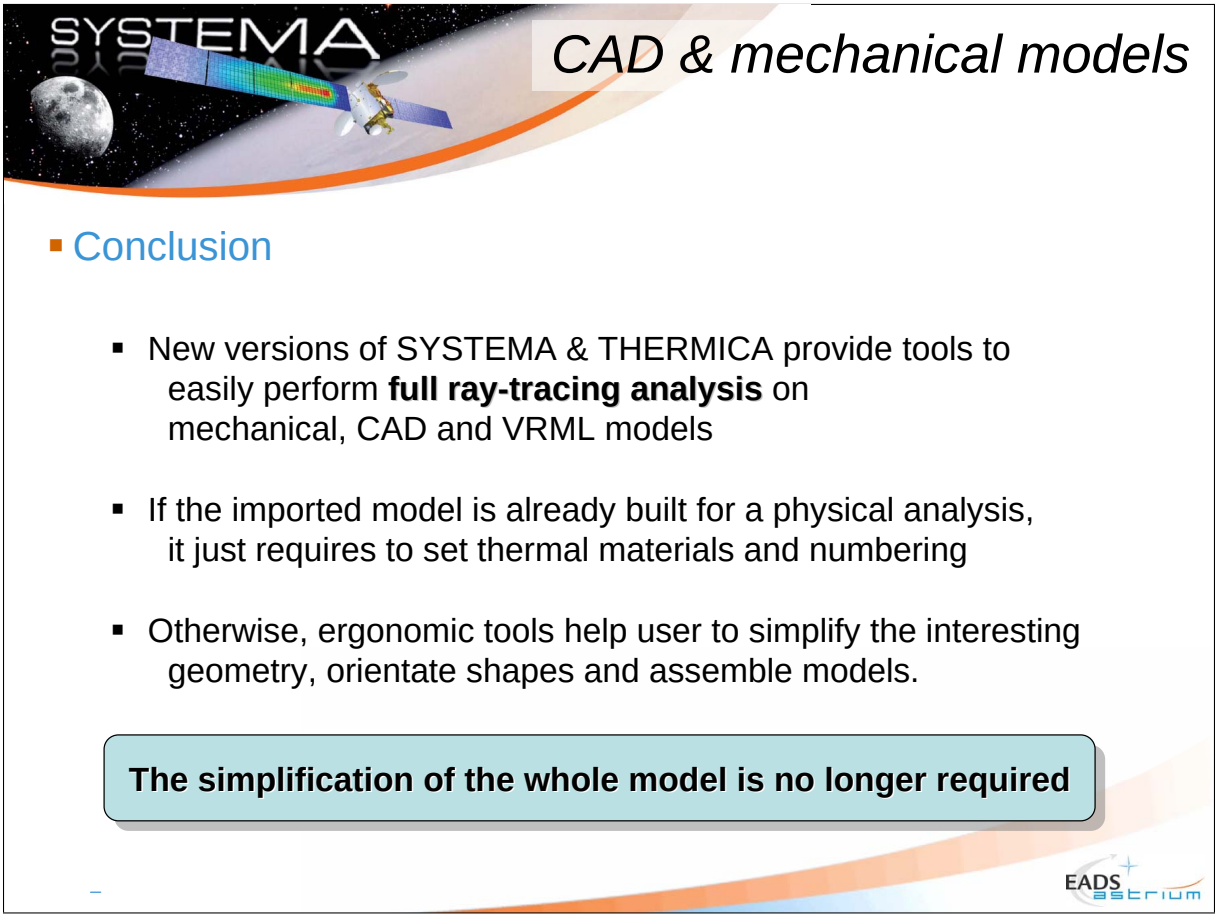
SYSTEMA
CAD & mechanical models
Conclusion
New versions of SYSTEMA & THERMICA provide tools to easily perform full ray-tracing analysis on mechanical, CAD and VRML models
If the imported model is already built for a physical analysis, it just requires to set thermal materials and numbering
Otherwise, ergonomic tools help user to simplify the interesting geometry, orientate shapes and assemble models.
The simplification of the whole model is no longer required
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SYSTEMA
STEP-TAS
Interface
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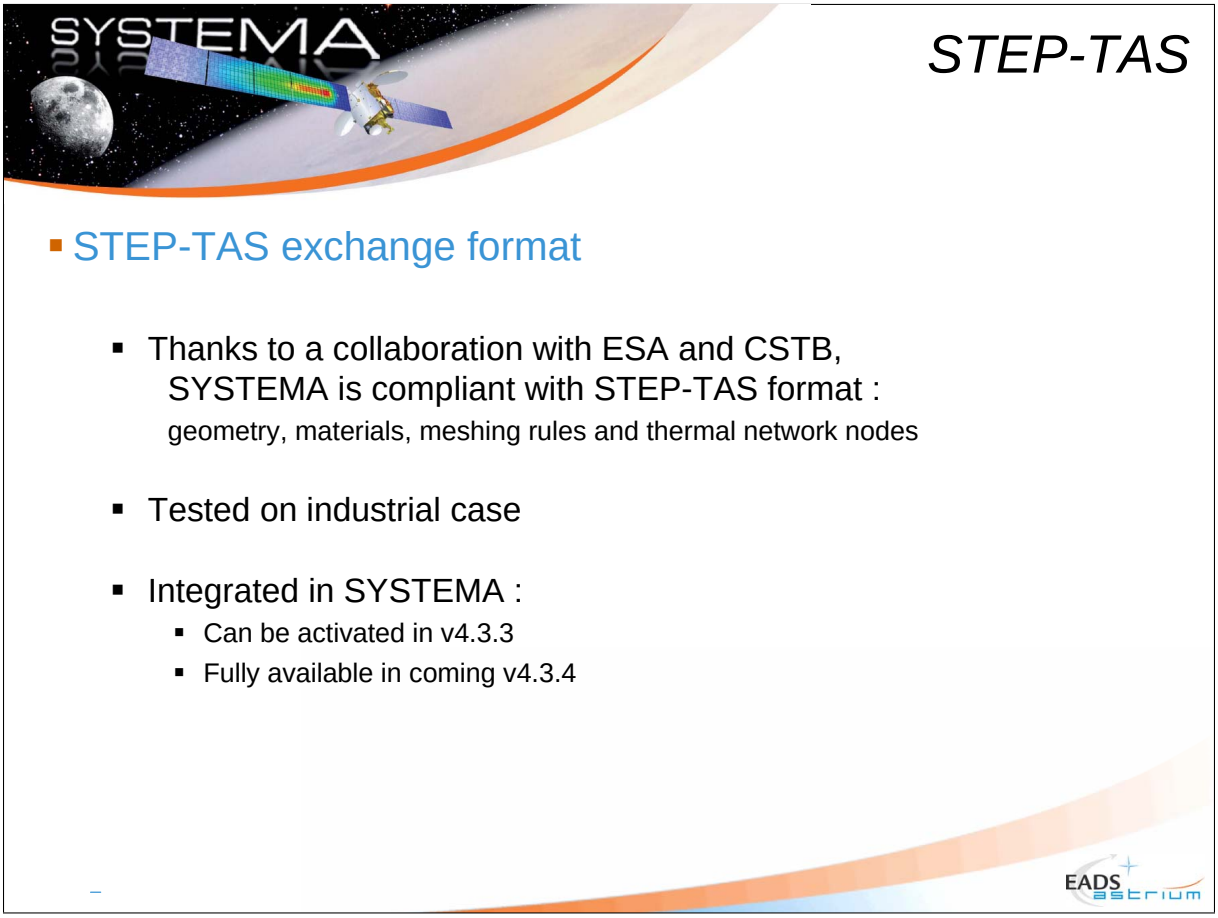
SYSTEMA
STEP-TAS
STEP-TAS exchange format
Thanks to a collaboration with ESA and CSTB, SYSTEMA is compliant with STEP-TAS format :
geometry, materials, meshing rules and thermal network nodes
Tested on industrial case
Integrated in SYSTEMA :
Can be activated in v4.3.3
Fully available in coming v4.3.4
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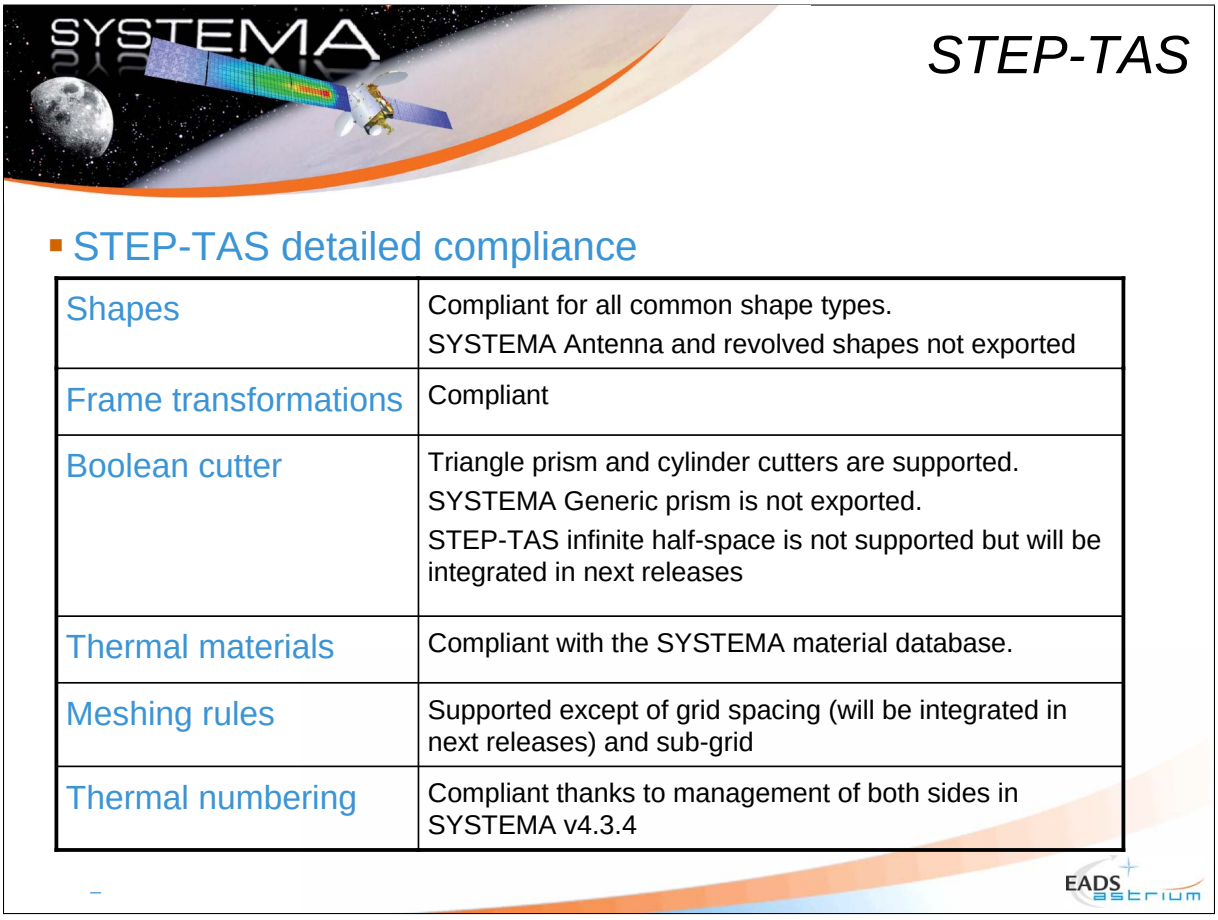
SYSTEMA
STEP-TAS
STEP-TAS detailed compliance
Shapes
Compliant for all common shape types.
SYSTEMA Antenna and revolved shapes not exported
Frame transformations
Compliant
Boolean cutter
Triangle prism and cylinder cutters are supported.
SYSTEMA Generic prism is not exported.
STEP-TAS infinite half-space is not supported but will be integrated in next releases
Thermal materials
Compliant with the SYSTEMA material database.
Meshing rules
Supported except of grid spacing (will be integrated in next releases) and sub-grid
Thermal numbering
Compliant thanks to management of both sides in SYSTEMA v4.3.4
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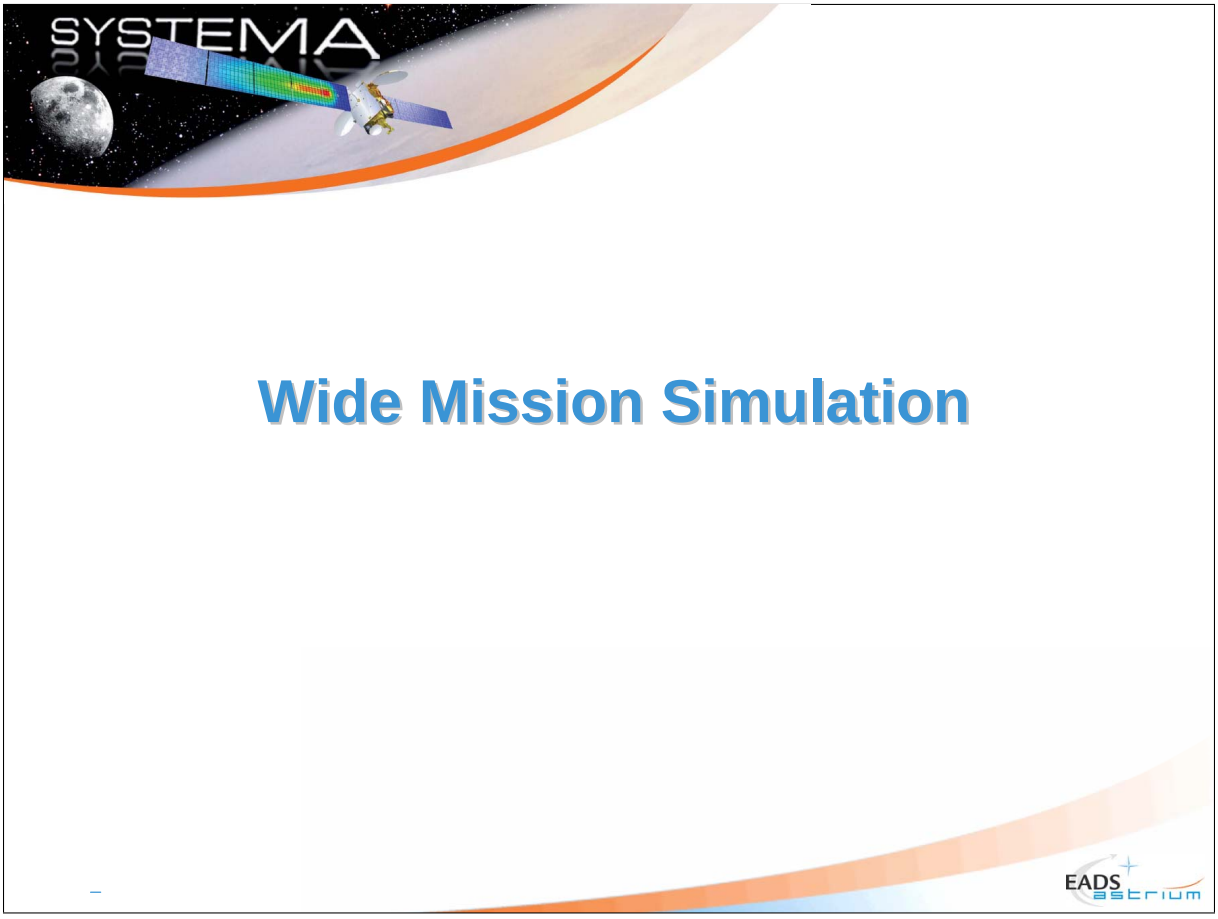
SYSTEMA
Wide Mission Simulation
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Wide mission simulation

- Analytic and realistic simulation
  - Realistic space mission
    - Ephemerids of solar system planets are computed by SYSTEMA :
      Mission is configured by giving dates of interest
  - Analytic parameters to define a worth case configuration
    - Dates of interests can be defined by:
      - Solar declination, Beta angle
      - Longitude and lattitude
      - Season dates (solstices and equinoxes)

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Wide mission simulation

- Mars Rovers and Ground Stations
  - SYSTEMA provide an easy way to define ground objects
    - Just longitude and latitude on the planet are required
  - Solar flux variations for THERMICA analysis
    - Daily variations due to the Mars rotational frame
    - Season variations due to the Mars orbit
  - Earth and Sun pointing laws
    - Beta angle and pointing misalignment can be displayed in real time

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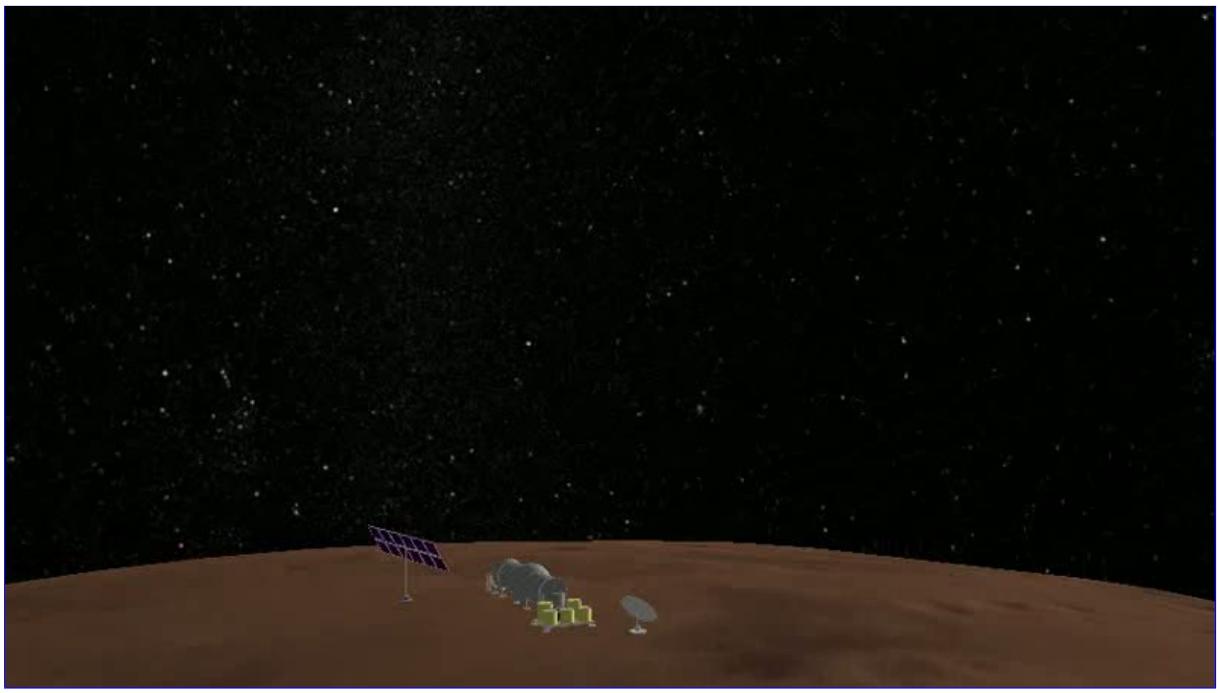
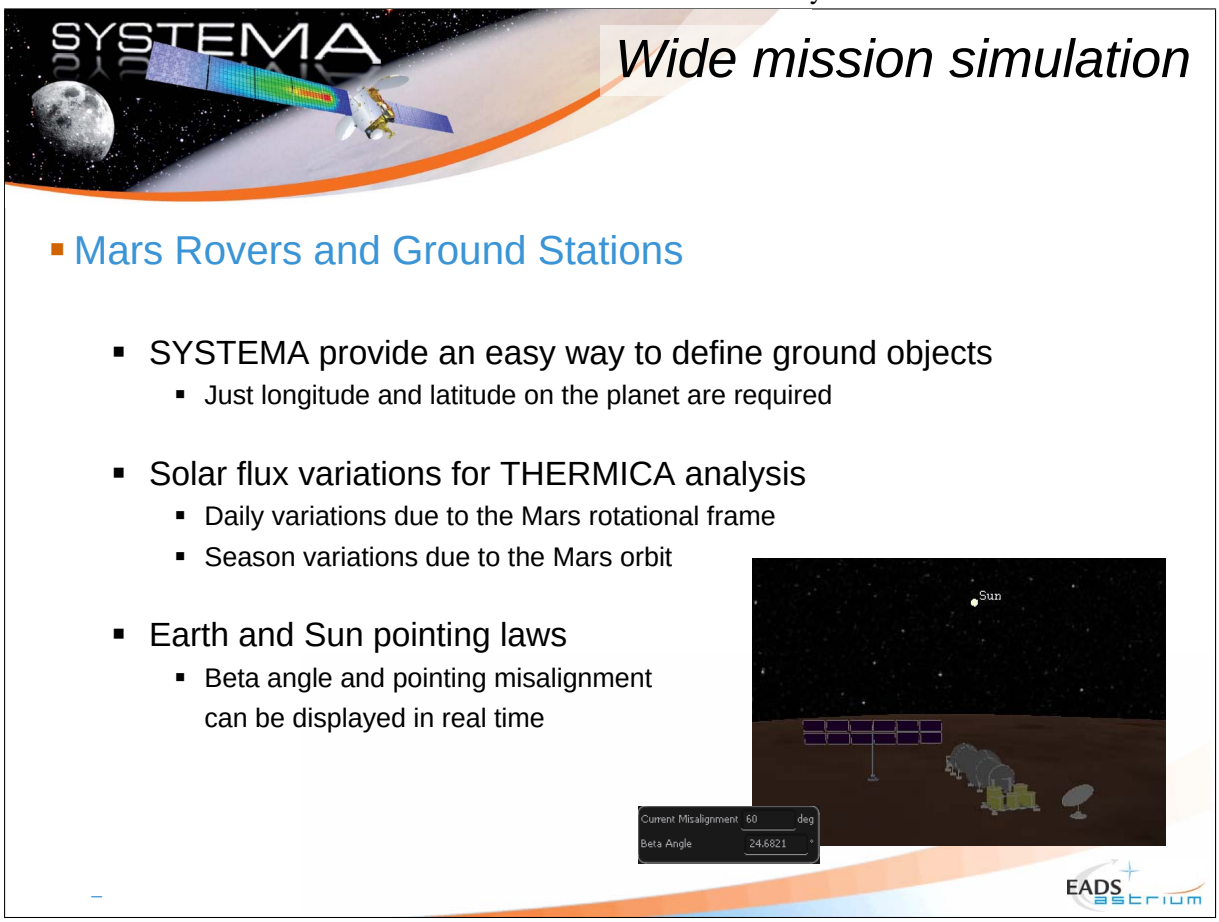
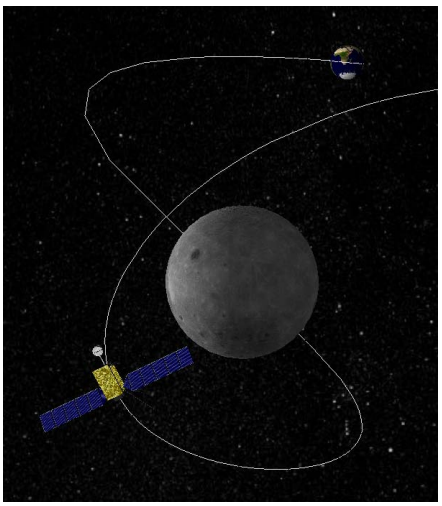


If clicking on the picture above does not run the movie then try opening the file ‘movies/MarsGround.html’ manually.

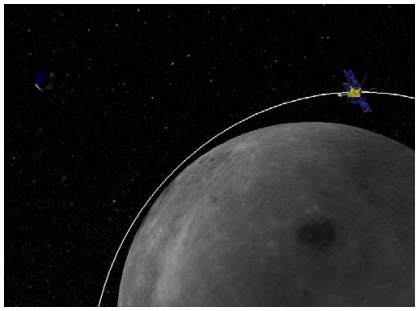


Wide mission simulation

- Moon orbiter



- Realistic Moon behaviour for solar and Moon albedo & IR fluxes
  - Daily and season rotations of Earth
  - Moon orbit and its rotational frame



- Dynamic follower camera
  - Camera Fixed in local orbital frame
  - View from / to Sun, the Earth or the Moon
  - Locking in planet rotational or inertial frame

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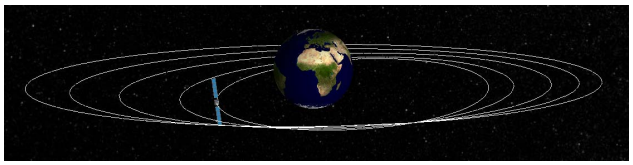
Wide mission simulation

- STK and CSV interfaces



- Both STK and CSV format are supported in import
  - STK : ephemerid .e format and attitude .a format
  - CSV : simple text files exported from Excel or other tools
- Trajectory satellite orbits
  - Position (and velocity in option) can be provided in cartesian or longitude / lattitude / altitude in rotational or inertial reference
  - Keplerian propagator or quadratic interpolation
- Kinematics attitude and behaviour
  - Attitude can be provided in quaternion or rotation matrix
  - Attitude are defined on a local orbital frame, a inertial frame or any pointing direction available in SYSTEMA

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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
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