Appendix T

Tests of solids implementation in ESATAN TMS R6

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Abstract

For Airbus DS Launchers development, the modelisation of the thermal phenomena inside a space vehicle needs a 3D volumic approach, in particular to represent heat transfer inside thermal protections and cavities and complex geometries. The methods based on shell elements are not well adapted to system thermal analyses. The implementation of solids in the software ESATAN TMS aims to answer to the needs of Airbus DS Vehicles Engineering.
In the frame of the development of ESATAN TMS R6 (including solids approach), Airbus DS Vehicles Engineering has tested some new functionalities for solids: volumes generation, meshing of these volumes, conductive contacts inside and between volumes (ACG), fluid/wall contacts, fluid/fluid contacts, cavities identification, radiative computations based on cavities ...
For the 28th European Space Thermal Analysis Workshop, Airbus DS Vehicles Engineering will present the results of the close collaboration between Airbus DS Vehicles Engineering and ITP Engines (ESATAN Provider) in the implementation of solids in the software ESATAN TMS R6 based on the validation test cases.

Tests of solids implementation in ESATAN TMS R6

28th European Space Thermal Analysis Workshop

Olivier FRAPSAUCE / Dominique FRAIOLI (Airbus DS Les Mureaux)
14/15 October 2014

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1. Thermal modelling needs on launcher side
2. Main requirements for ESATAN-TMS R6
3. Quick overview of new functionalities
4. Tests on new ESATAN-TMS R6 functionalities

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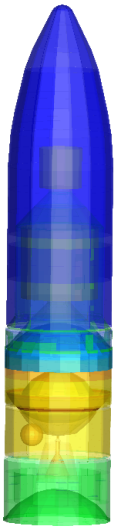
Tests of solids implementation in ESATAN TMS R6 - Airbus DS Les Mureaux

1. Thermal modelling needs on launcher side

On launcher side, the thermal model includes volumic conductive model associated to radiative and convective part.

The Airbus DS qualified (A5ECA version) process allows to use DMU to build the conductive model based on volumes and to generate automatically the geometrical mathematical model needed for radiative and convective exchanges.

The previous ESATAN TMS R5 version, using shell did not answer to the need > FDS for introduction of volumes into ESATAN TMS



FDS : Functional and Development Specification

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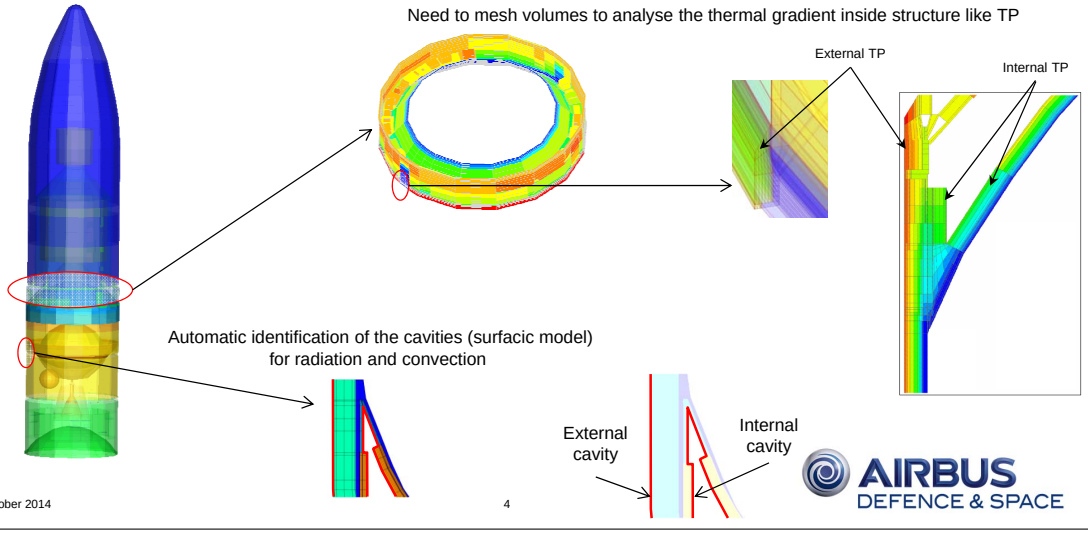
1. Thermal modelling needs on launcher side



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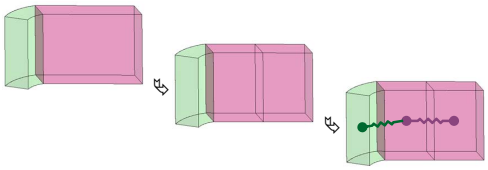
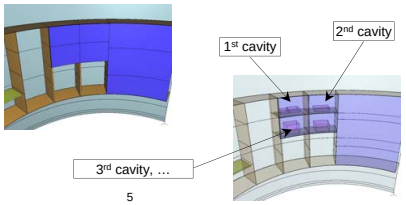
2. Main requirements for ESATAN-TMS R6

- To work with a volumic geometry in the graphical interface
  - Creation of solids
  - Meshing definition
  - Automatic Conductor Generation
    - Inside solids
    - Between two adjacent solids



- Creation of cavities
  - Cavity = set of surfaces used for a radiative and/or convective analysis
  - Automatic detection of the cavities



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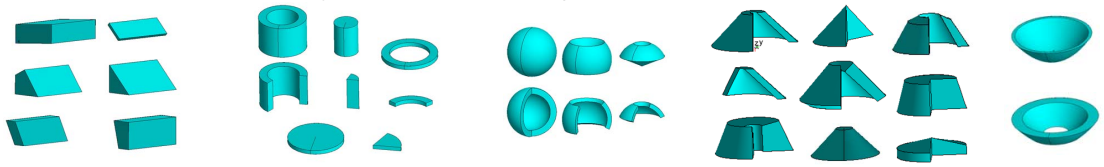
3. Quick overview of new functionalities

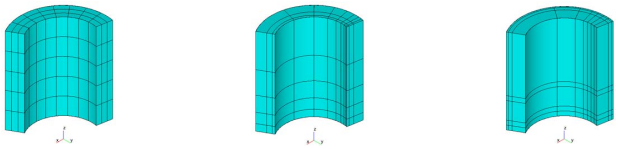
- Solid geometries

Quadrilaterals Cylinders Spheres Cones Paraboloids



- Meshing

Regular Ratio Any



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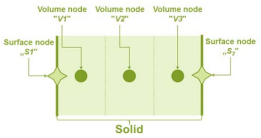
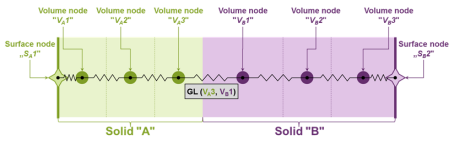
3. Quick overview of new functionalities

- Nodes definition
  - Solid geometry meshed in volumic nodes
  - External surfaces of the solid geometry defined as non-capacitive nodes
    (6 surface nodes per solid)

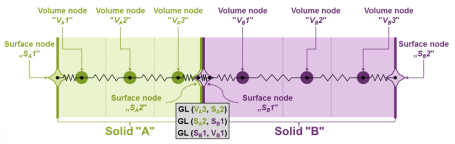


- ACG
  - Automatic contact recognition and couplings calculation using Far Field method
  - Contact processing :

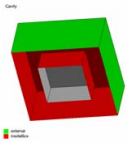
Fused option *(default option)*



Contact option



- Cavities recognition via view factors calculation



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4. Tests on new ESATAN-TMS R6 functionalities

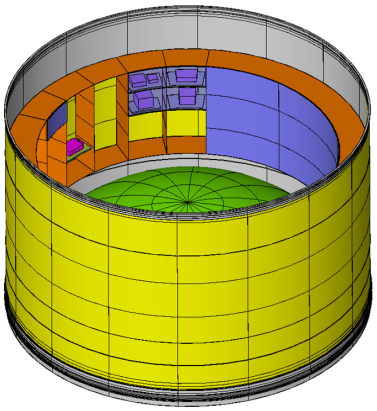
- Geometry & Meshing
  - Test case based on an Ariane 5 EPC upper part geometry

- Conductive couplings
  - Elementary tests with basic geometries (cylinders, spheres) :
    Comparison of calculated coupling values vs analytical formulae

    ↳In ESATAN-TMS R6 sp2, couplings values are considered valid.

  - Application on the Ariane 5 EPC upper part geometry

    ↳But the implementation of anisotropy is missing.



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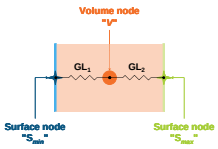
Elementary tests for conductive couplings

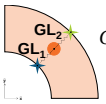
- Test Method
  - Creation of a single volume & Generation of the analysis file



  - Comparison of the calculated couplings (GL_1, GL_2 & GL_{eq}) with the analytical values

$$Deviation = \frac{GL^{analytical} - GL^{TMS\ R6sp2}}{GL^{analytical}}(\%)$$

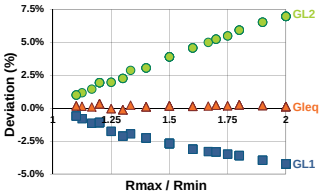
- Example : Cylinder
  - Radial Direction (R)

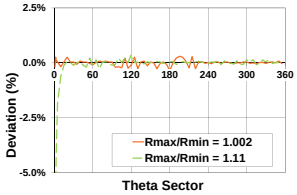


$$GL_{eq} = \frac{1}{\frac{1}{GL_1} + \frac{1}{GL_2}}$$

  - Angular Direction (θ)

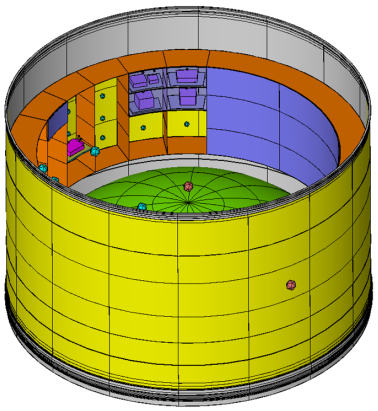
$$GL_{eq} = GL_1 = GL_2$$





4. Tests on new ESATAN-TMS R6 functionalities

- Convective couplings
  - Application on the Ariane 5 EPC upper part geometry
  - Currently only direct convective coefficient h is available, the use of convective coefficient temperature dependent as $k.\Delta T^{\alpha}$ is not available in the interface.
- Advective couplings (fluid channels)
  - Application on the Ariane 5 EPC upper part geometry
  - Currently only fixed value of specific heat is available in the interface (no temperature dependance).



4. Next steps

R6 fonctionnalities still to be tested

– Cavities identification for radiative/convective model generation and for radiative fluxes computations

Other validations for our new process

– capability to control that all the surfaces of the cavities are coupled with gas nodes
– Export capability (model exchange, model assembly, …)
– Compatibility with our internal tools (end to end process)

⇒According to these tests, new needs should be defined for addition in next ESATAN TMS version.

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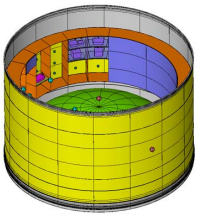
Thanks for your attention





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