

Appendix C

The Use of ESATAN-TMS r3 software for Ray Tracing Visualisation

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Abstract

The presentation will demonstrate the benefits of the ray tracing visualisation software, briefly describe how it works and discuss how it has been beneficial to current projects.

The Use of ESATAN-TMS r3 software for Ray Tracing Visualisation

Astrium Ltd Thermal Analysis Group (UK)

Stevenage

Roisin Speight / Alex Jacobs

8-9 November 2011

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Presentation Content

- Background – why is visualisation useful?
- How ray visualisation is used
- Useful tips for using ray visualisation
- Examples of implementation
 - Solar Orbiter
 - Bepi Colombo

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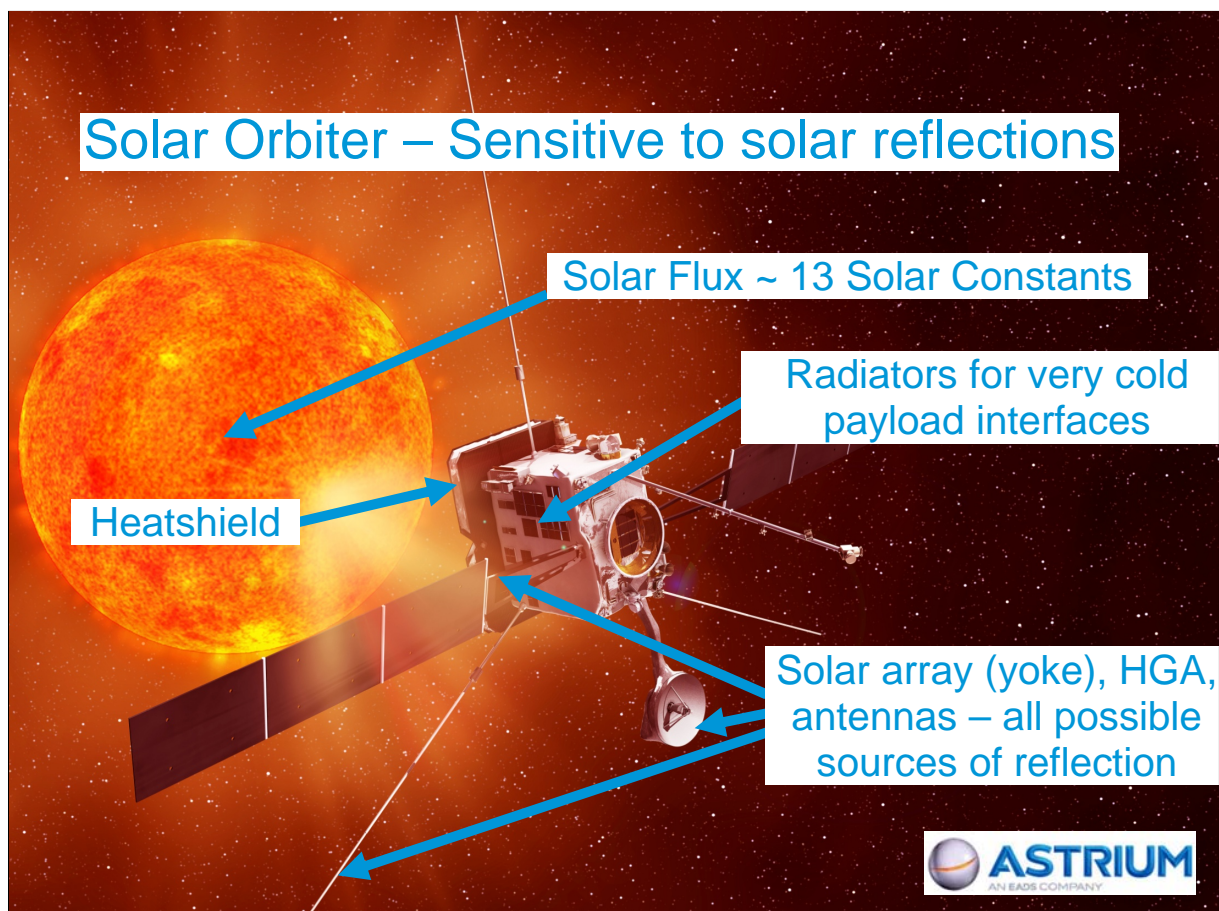


Why use ray visualisation?

- All spacecraft are sensitive to reflected light from appendages
- On its closest approach to the sun, at 0.28 AU, Solar Orbiter will be particularly sensitive to such reflections
- The paths of reflected rays between components are not always easy to identify
- Multiple reflections are extremely difficult to understand without some form of visualisation

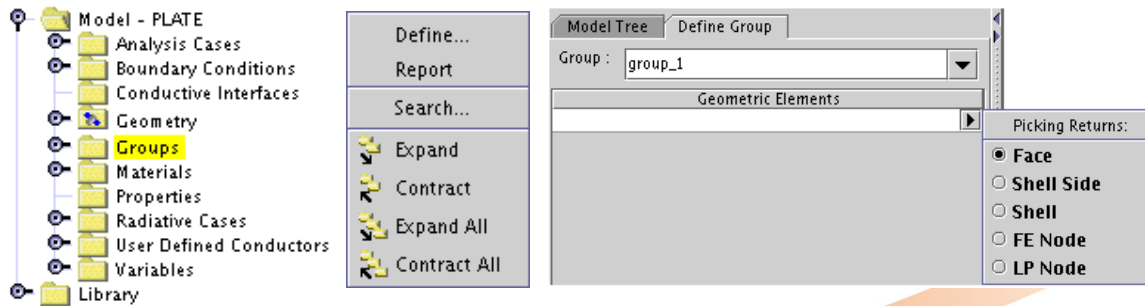
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Using ESATAN-TMS r3 software for Ray Tracing Visualisation

- **Defining a group:**
 - Groups must be defined by face or shell
 - I.e. NOT by node – ray information is not stored for nodes only faces



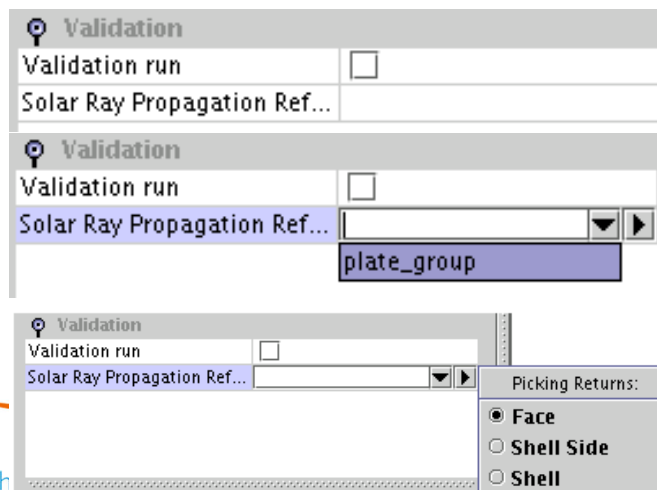
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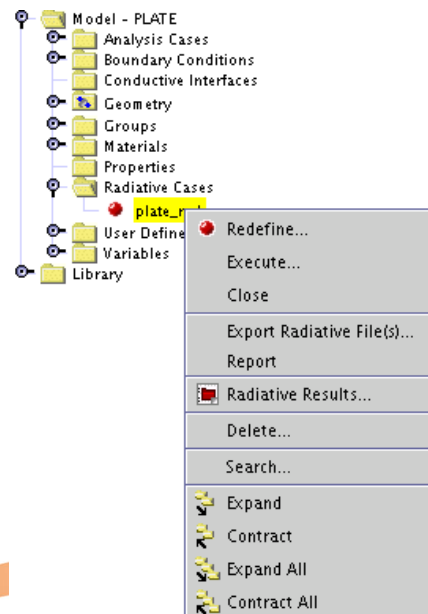
Using ray visualisation - GUI

- **Executing radiative case:**
 - Open radiative case
 - Select «Execute»
 - Opens «Execute» dialogue box



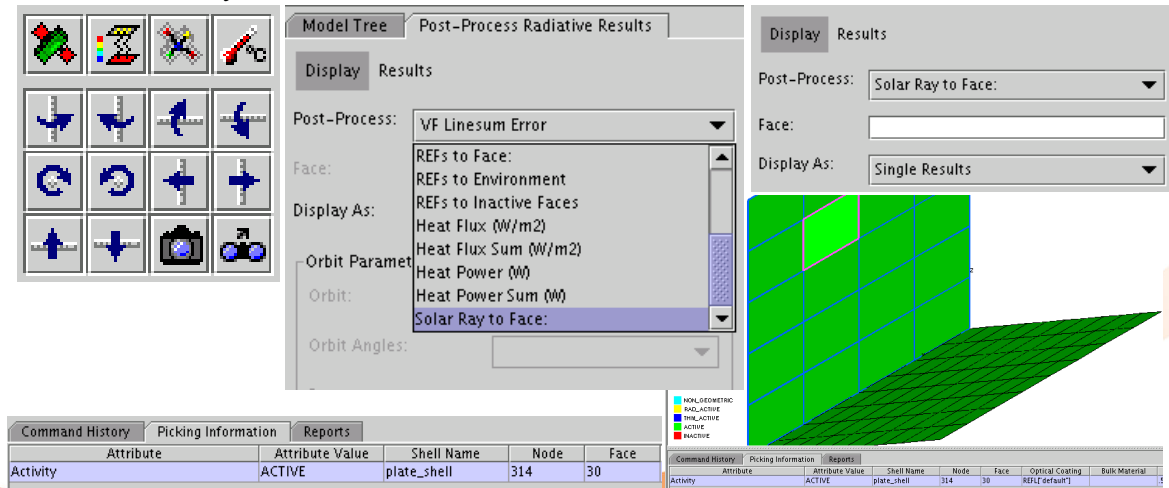
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Using ray visualisation - GUI

- Visualising rays:
 - Ray visualisation

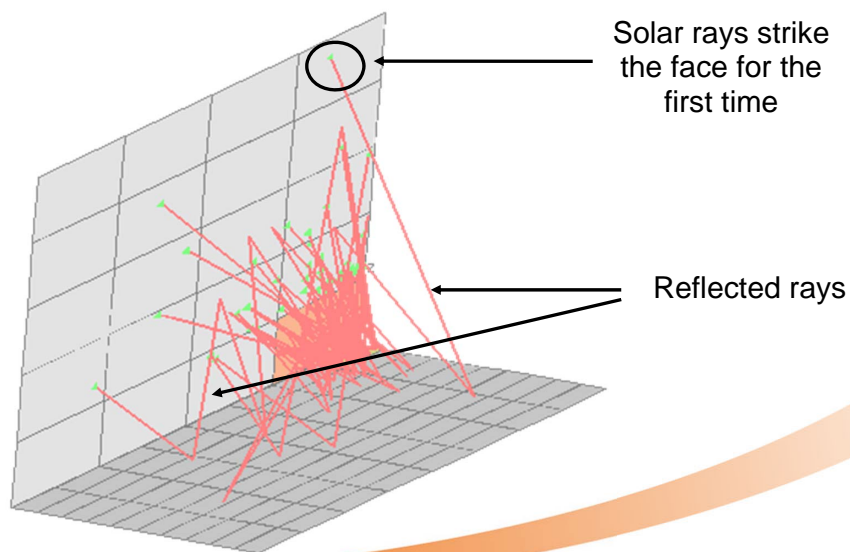


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Using ray visualisation - GUI



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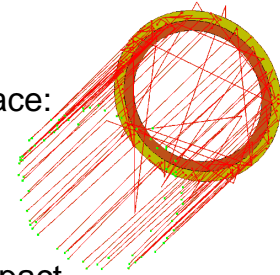


Using ray visualisation - GUI

■ Terminology

- Solar Ray Propagation Reference/Reference Face:
 - Individual Face
 - Individual Shell
 - Group of Faces
 - All solar rays (direct and reflected) which impact these shells/faces are stored for post-processing

- Selected face:
 - Face of interest - chosen during post-processing to display all rays which impact it.



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General User Tips

■ Things to be aware of:

- Number of rays
- Ray tracing algorithms are performed based on geometry.
- Cannot define reference or selected face by node number.

■ Good practices:

- Always check the apparent results from ray visualisation against solar flux and temperature maps.
- Also check against hand calculations.

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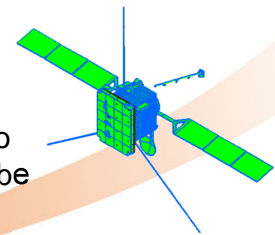
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Example of implementation – Solar Orbiter

Solar Orbiter Problem:

- Investigate the specular reflections from the solar array yoke onto the spacecraft Y walls at the point where the reflections will be most critical
 - With the solar array at 75.5 degree inclination
 - At closest approach to the sun (0.28 AU)
- Determine the optimum baseline yoke design which will minimise the reflected flux and subsequent increase in temperature of the critical components and therefore have minimal thermal impact on the spacecraft.
- This investigation was carried out pre-PDR. The purpose to identify the magnitude of the problem (if any) so that it can be discussed with the selected supplier and the risk minimised at an early stage.

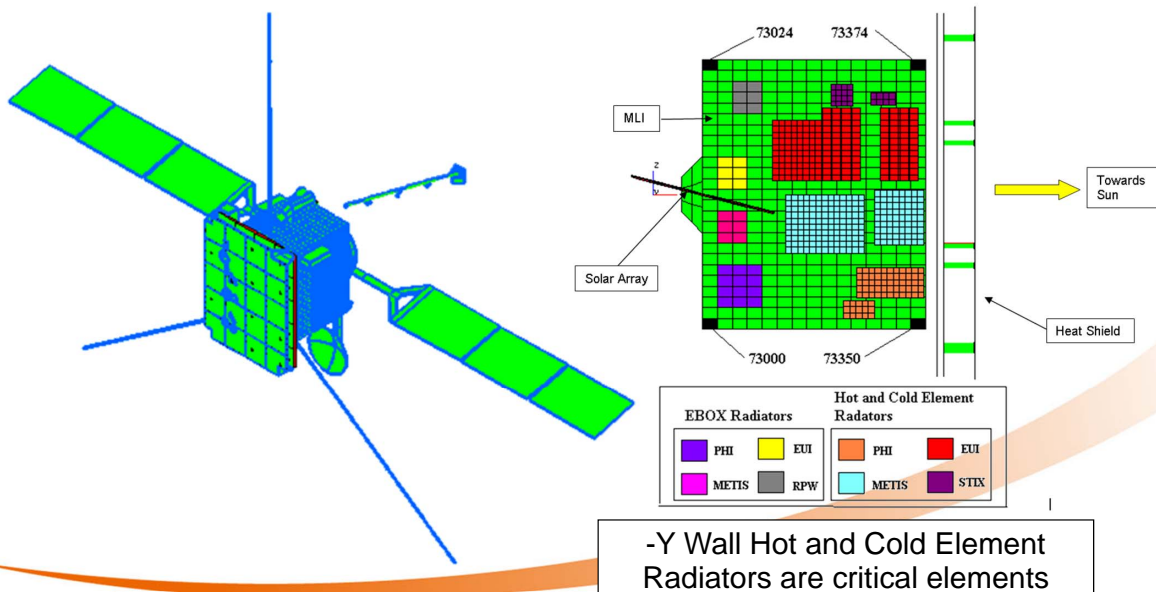


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Example of implementation – Solar Orbiter

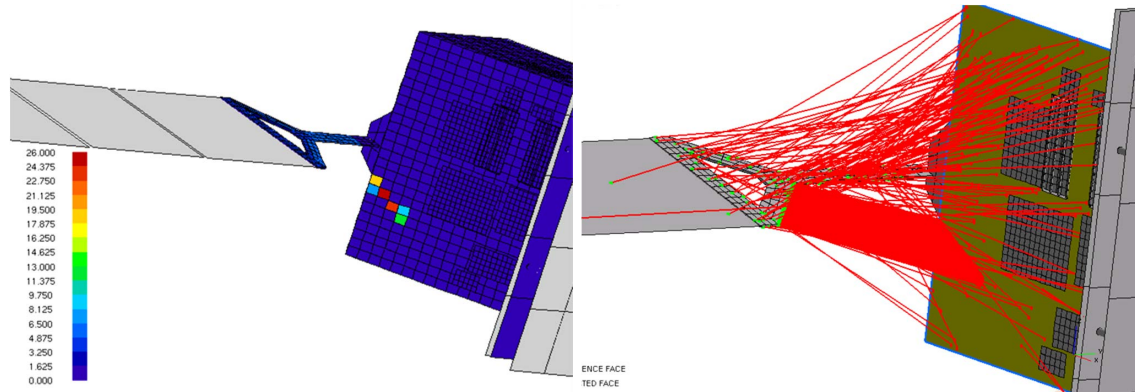


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Example of implementation – Solar Orbiter



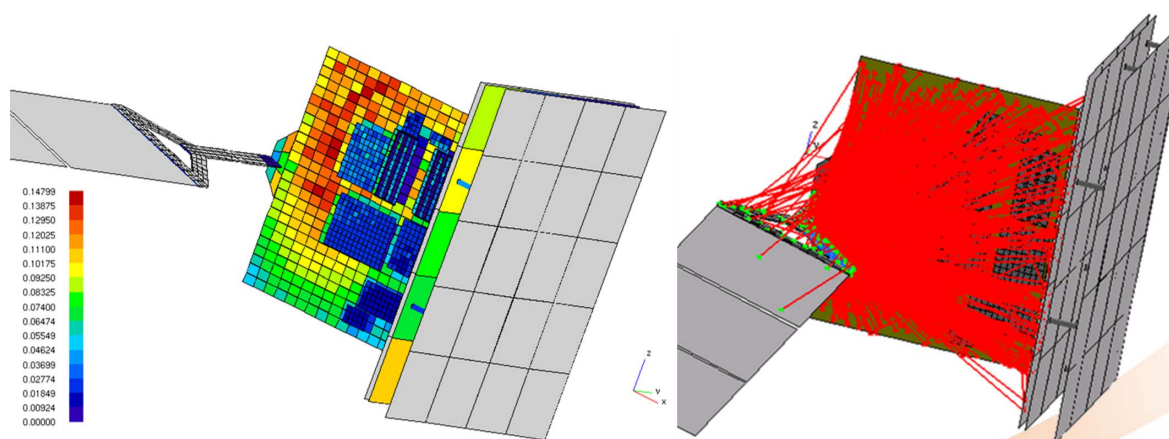
- Solar array yoke assumed coated in fully specular OSRs
- Reflected rays are concentrated in a localised region

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Example of implementation – Solar Orbiter



- Solar array yoke assumed coated in fully diffuse OSRs
- Reflected rays are scattered

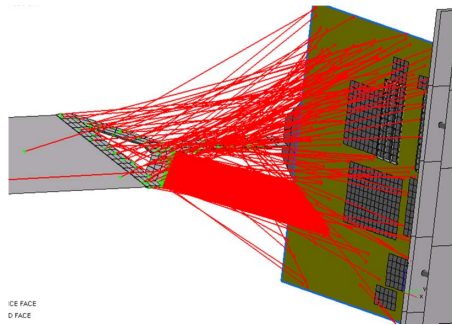
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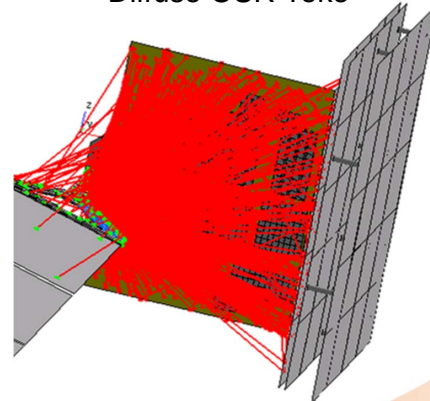


Example of implementation – Solar Orbiter

Specular OSR Yoke



Diffuse OSR Yoke



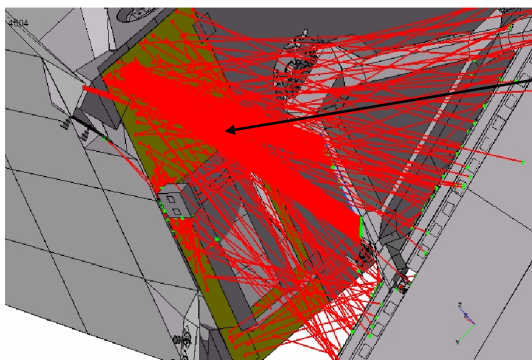
For solar orbiter the reflected flux from specular OSR yoke is the preferred baseline solution. Although the flux concentration is higher, the effect is localised and therefore easier to thermally control.

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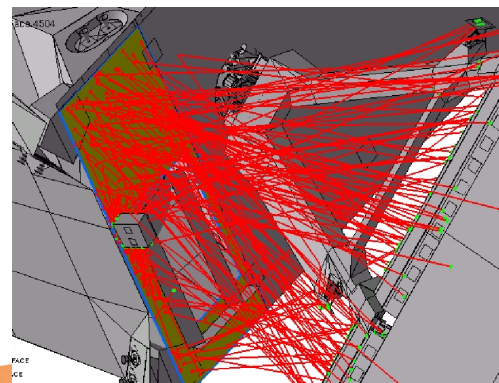


Example of implementation – Bepi Columbo



Ray tracing software shows that the solar array yoke angle causes flux concentration on the radiator panel.

With this information the thermal engineer can show how a design change will reduce the flux concentration problem



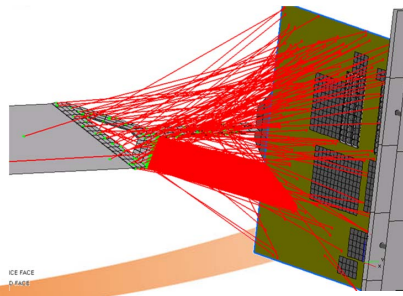
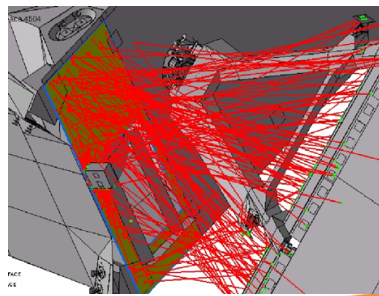
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Conclusion

- ESATAN-TMS r3 software for Ray Tracing Visualisation has proven to be a very useful tool for Astrium UK
- The visualisation of rays enables the 'problem face' to be easily identified
- The tool has enabled further understanding of solar flux reflections at close proximity to the sun where additional reflections from appendages are thermal design drivers



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