

Appendix S

Model reduction of Sentinel 1

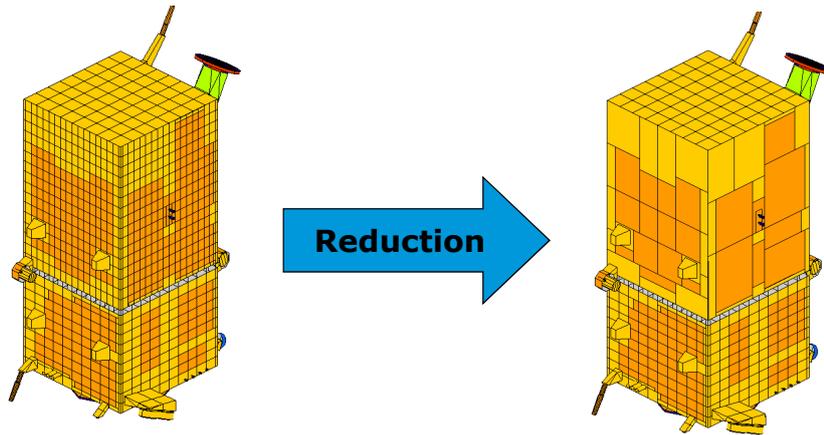
Daniel Kintea
(ESA/ESTEC, The Netherlands)

Abstract

This presentation is intended to give a brief overview on the thermal model reduction using the Thermal Model Reduction Tool on the Sentinel-I satellite. It also shows the capabilities and restrictions of the reduction method and the tool.



Model reduction of the Sentinel-I using the TMRT



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Introduction



Model reduction ...

- ... reduces computation time
- ... ideally keeps the input-output behavior of the detailed model

TMRT*...

- ... stands for **T**hermal **M**odel **R**eduction **T**ool
- ... is developed under GSTP contract by Astrium, Thales Alenia Space and Dorea

This presentation ...

- ... gives an overview of the usage of the TMRT applied to a real orbital case of the Sentinel-I**
- ... shows the potential of the model reduction
- ... shows the restrictions of the reduction

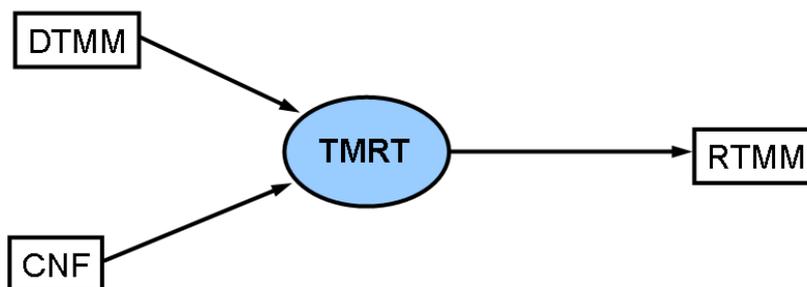
*) previously presented at this Workshop in 2010 [Mathieu Bernard (EADS Astrium, France), Thierry Basset (Thales Alenia Space, France), James Etchells (ESA/ESTEC, The Netherlands): TMRT]

***) Component of EU & ESA's Global Monitoring for Environment and Security Programme (GMES), Thales Alenia Space is Satellite prime contractor, EADS Astrium GmbH is the instrument responsible.

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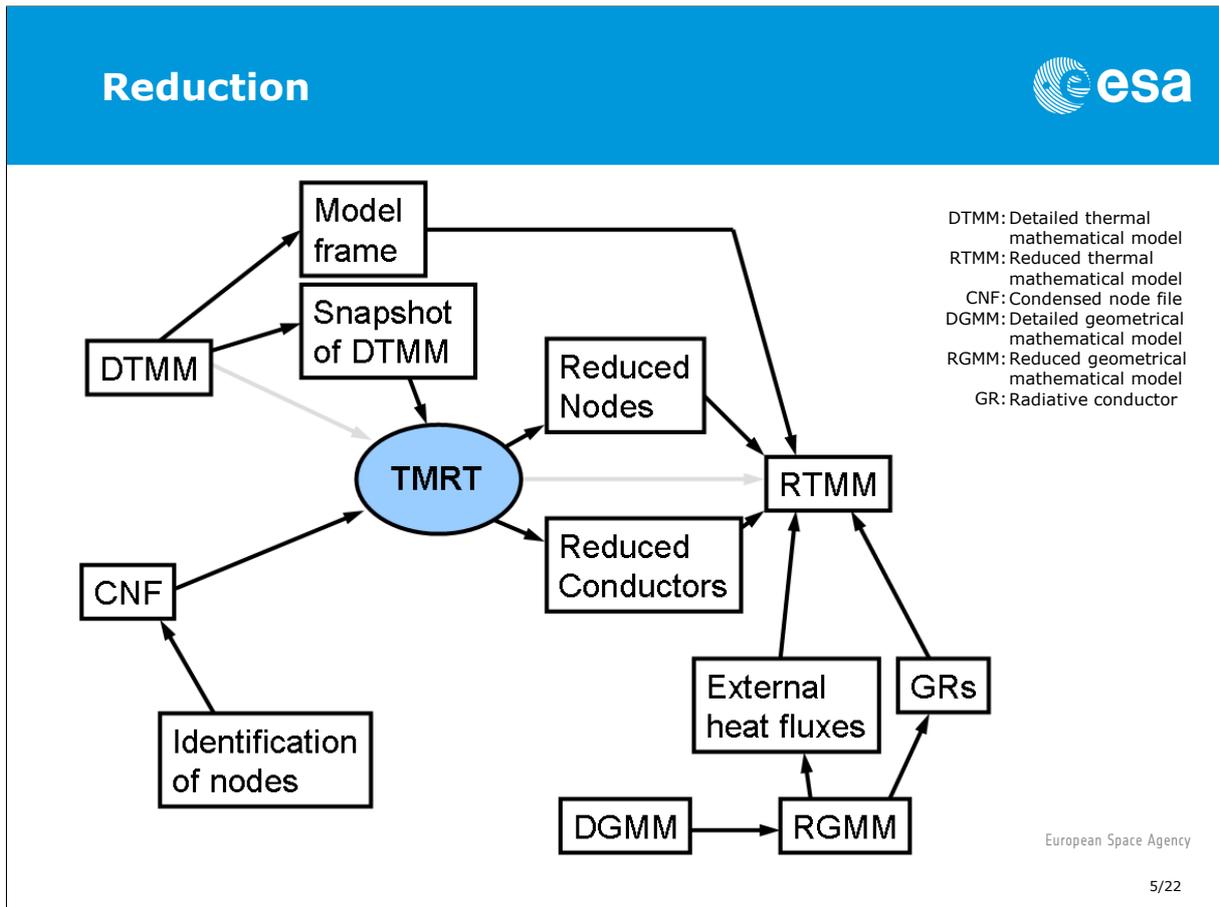
Reduction



DTMM: Detailed thermal mathematical model
 RTMM: Reduced thermal mathematical model
 CNF: Condensed node file
 DGMM: Detailed geometrical mathematical model
 RGMM: Reduced geometrical mathematical model
 GR: Radiative conductor

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The stowed model

Model is courtesy of Thales Alenia Space

LEOP CASE H11:

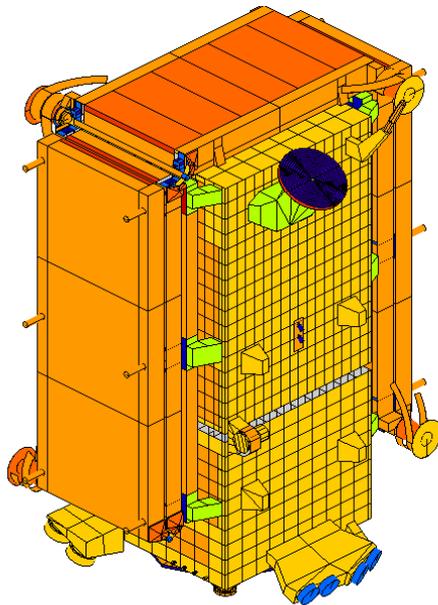
- Solar inputs 1420 W/m² (WS)
- Sun-synchronous orbit
- Mission phase: LEOP Contingency
- Pitch rate -0.0608°/s
- Configuration: STOWED

Requirements for RTMM:

- $\Delta T_{\text{Equipment}} < 3 \text{ K}$
- $\Delta T_{\text{Structure}} < 5 \text{ K}$
- $\Delta T_{\text{MLI}} < 10 \text{ K}$
- $\Delta P_{\text{Heater}} < 5 \%$

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The stowed model



Model is courtesy of Thales Alenia Space

LEOP CASE H11:

- Solar inputs 1420 W/m² (WS)
- Sun-synchronous orbit
- Mission phase: LEOP Contingency
- Pitch rate -0.0608°/s
- Configuration: STOWED

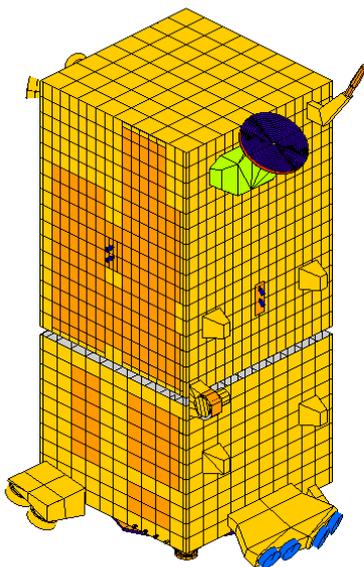
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The stowed model



Model is courtesy of Thales Alenia Space

LEOP CASE H11:

- Solar inputs 1420 W/m² (WS)
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- Mission phase: LEOP Contingency
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- Configuration: STOWED

Requirements for RTMM:

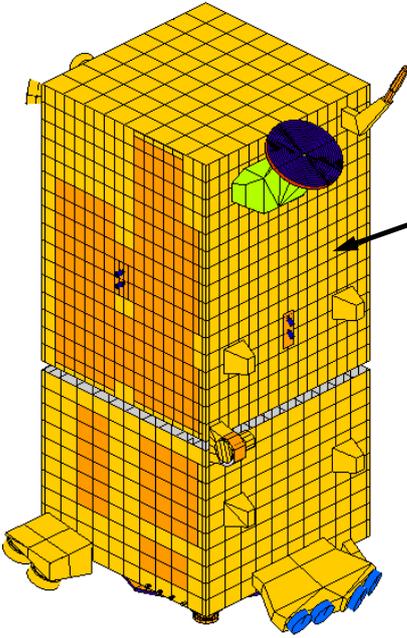
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Reduction of the -Y PLM Panel





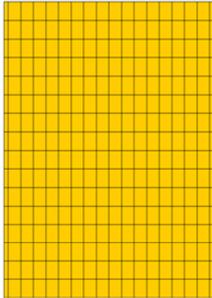
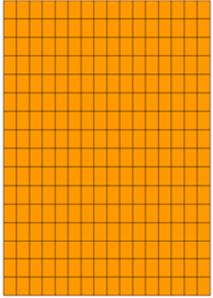
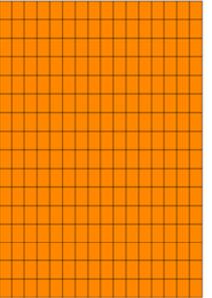
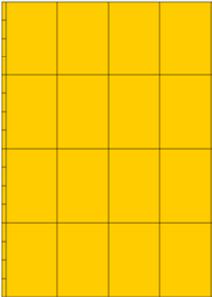
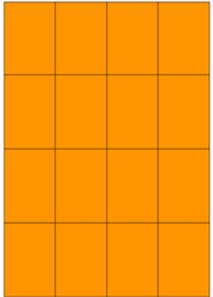
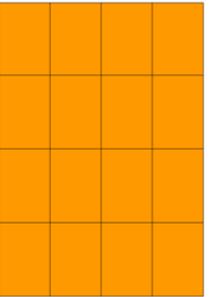
-Y PLM Panel,
3x16x16 nodes



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Reduction of the -Y PLM Panel

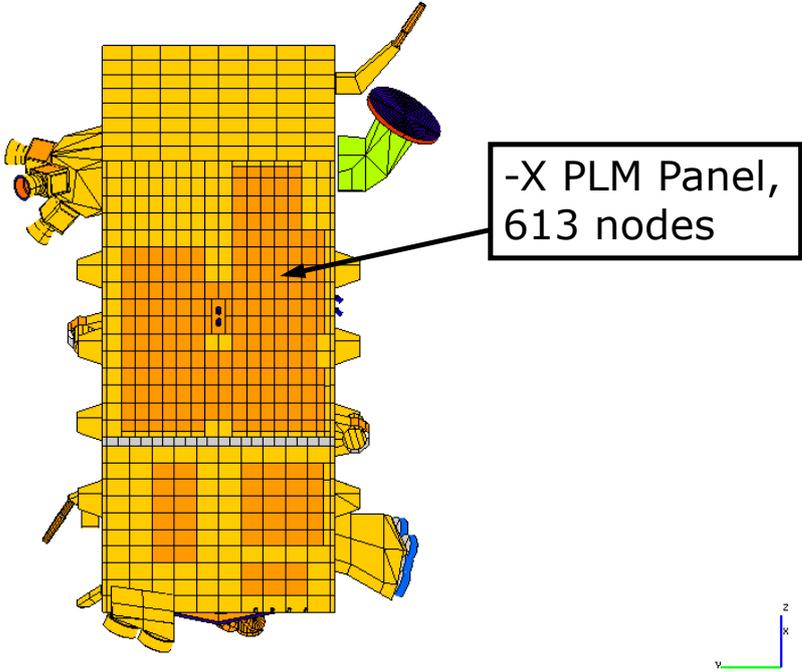


			<div style="border: 1px solid black; padding: 5px; display: inline-block;">DTMM</div> <p>532 shells 768 nodes</p>
<div style="border: 1px solid black; padding: 5px; display: inline-block;">MLI</div>	<div style="border: 1px solid black; padding: 5px; display: inline-block;">Outer panel</div>	<div style="border: 1px solid black; padding: 5px; display: inline-block;">Inner panel</div>	<p>⇒ 93.8 % of the nodes condensed ⇒ 90.2 % of the shells condensed</p>
			<div style="border: 1px solid black; padding: 5px; display: inline-block;">RTMM</div> <p>52 shells 48 nodes</p>

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Reduction of the -X PLM Panel



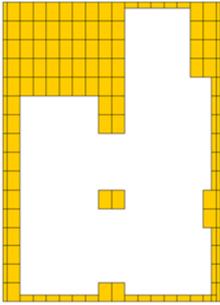
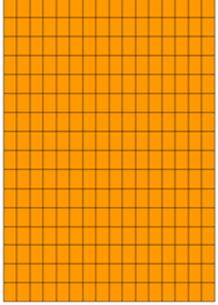
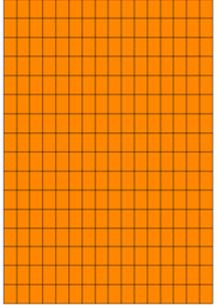
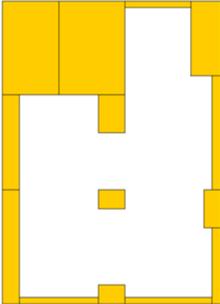
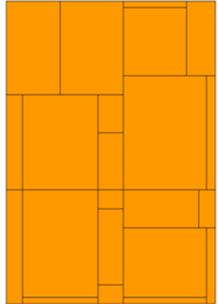
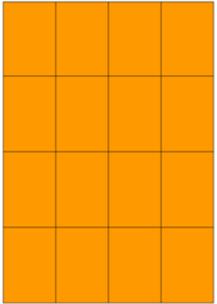


-X PLM Panel,
613 nodes

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Reduction of the -X PLM Panel

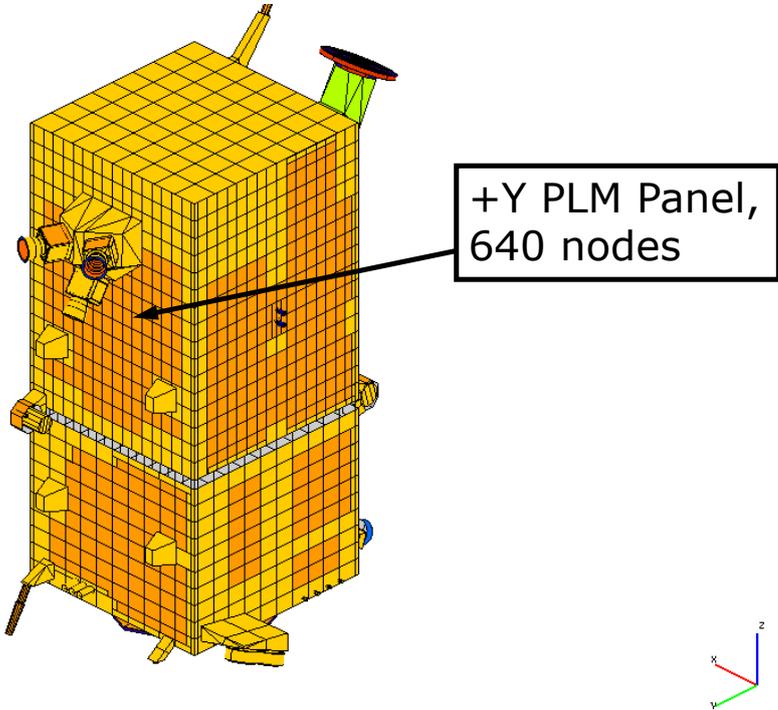


 <p style="border: 1px solid black; padding: 2px; width: fit-content; margin: auto;">MLI</p>	 <p style="border: 1px solid black; padding: 2px; width: fit-content; margin: auto;">Outer panel</p>	 <p style="border: 1px solid black; padding: 2px; width: fit-content; margin: auto;">Inner panel</p>	<div style="border: 1px solid black; padding: 5px; display: inline-block; margin-bottom: 10px;">DTMM</div> <p>571 shells 613 nodes</p> <p>⇒ 91.5 % of the nodes condensed ⇒ 93.4 % of the shells condensed</p>
			<div style="border: 1px solid black; padding: 5px; display: inline-block; margin-bottom: 10px;">RTMM</div> <p>38 shells 52 nodes</p>

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Reduction of the +Y PLM Panel



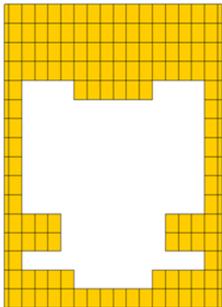
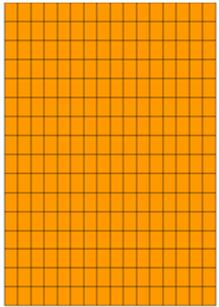
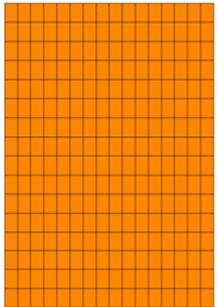
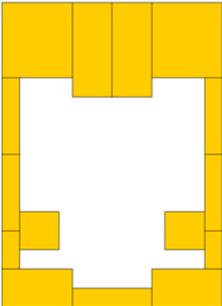
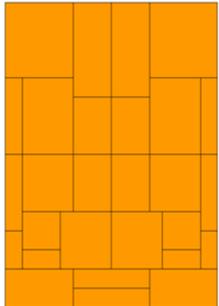
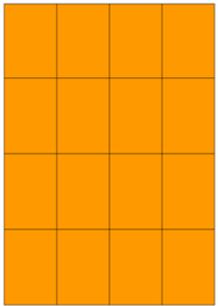


+Y PLM Panel,
640 nodes

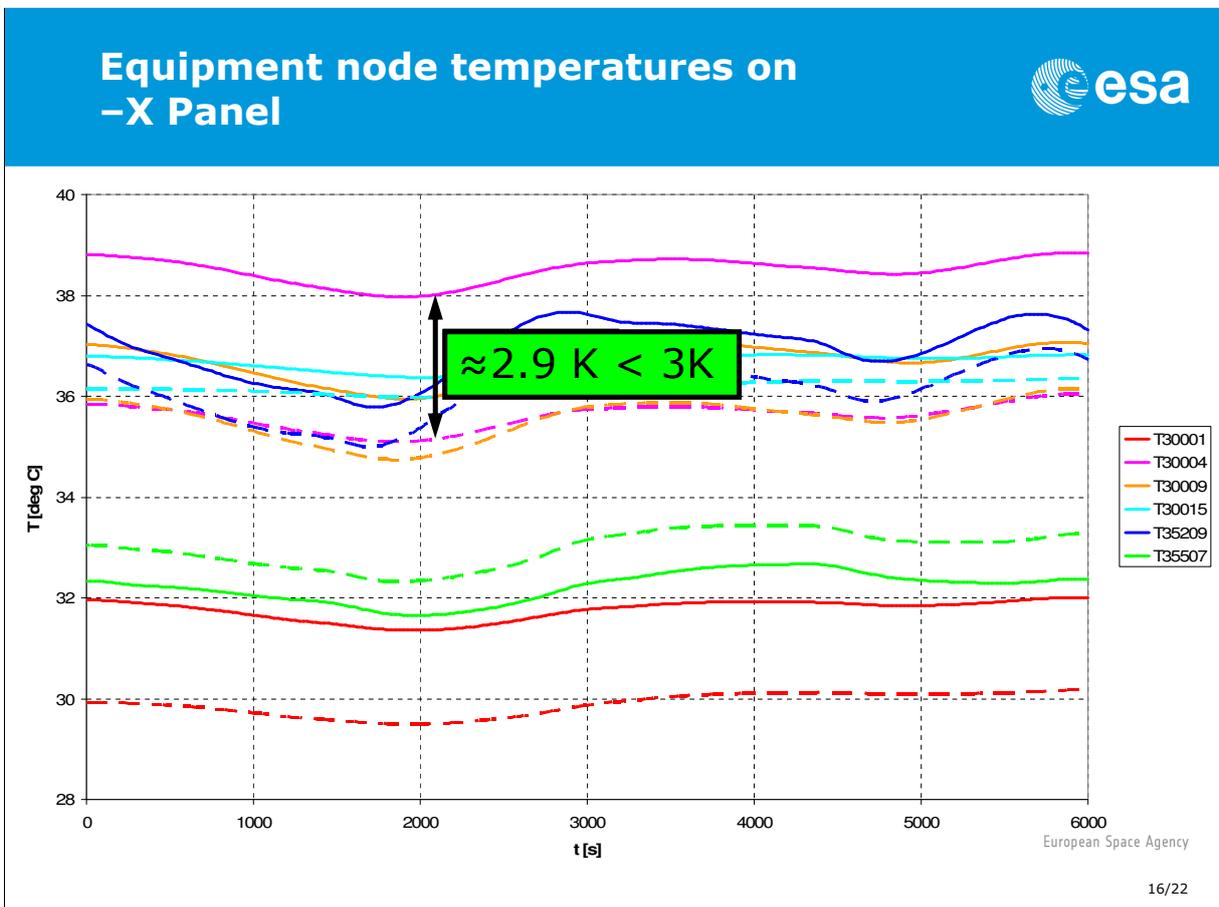
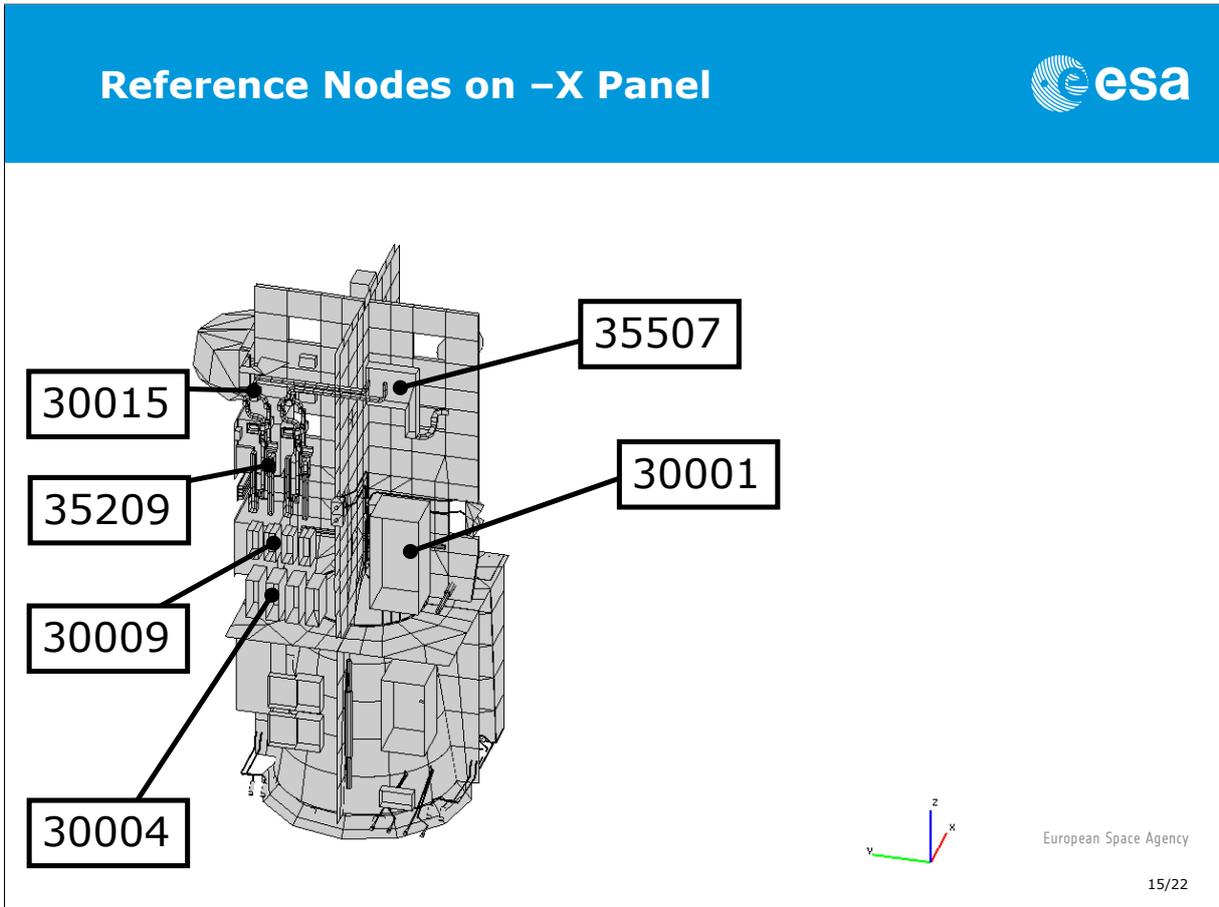
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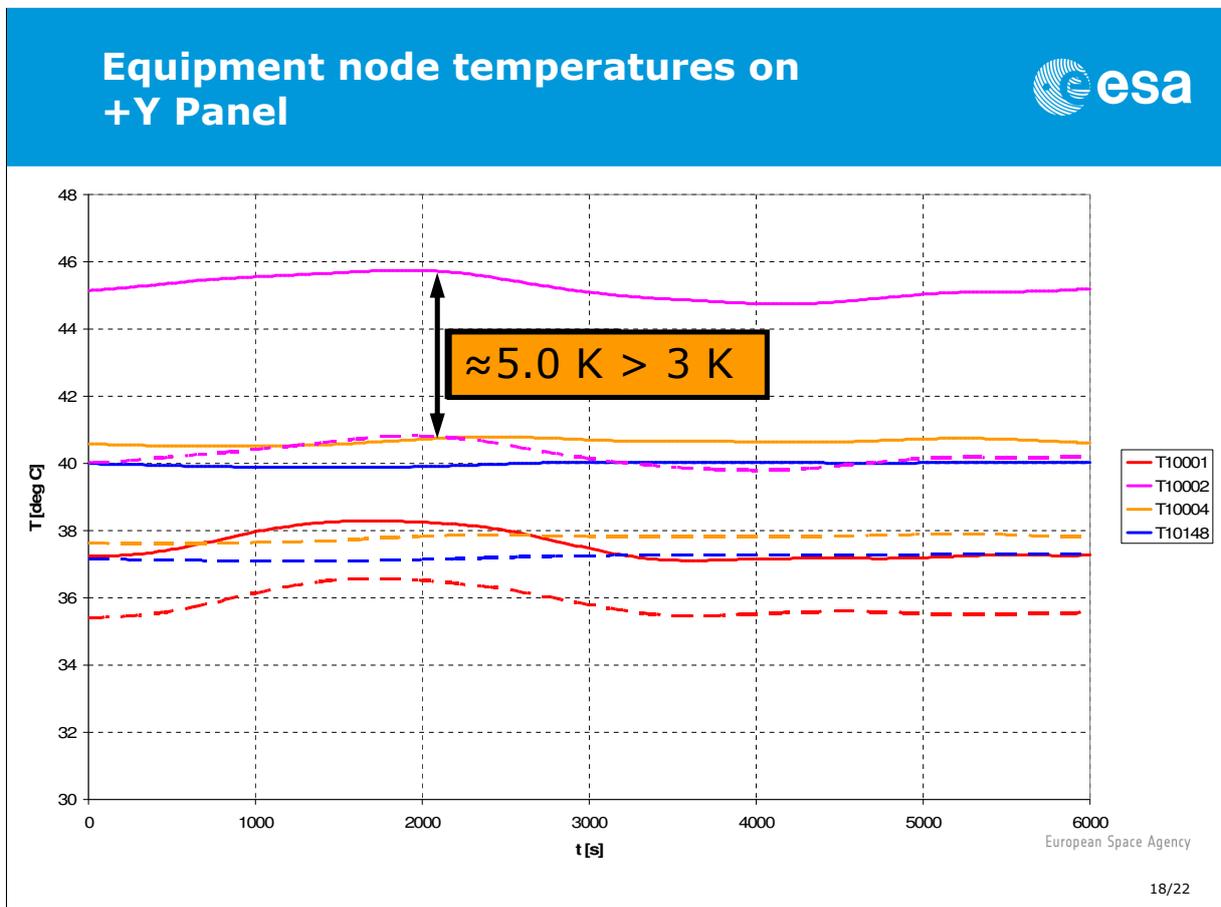
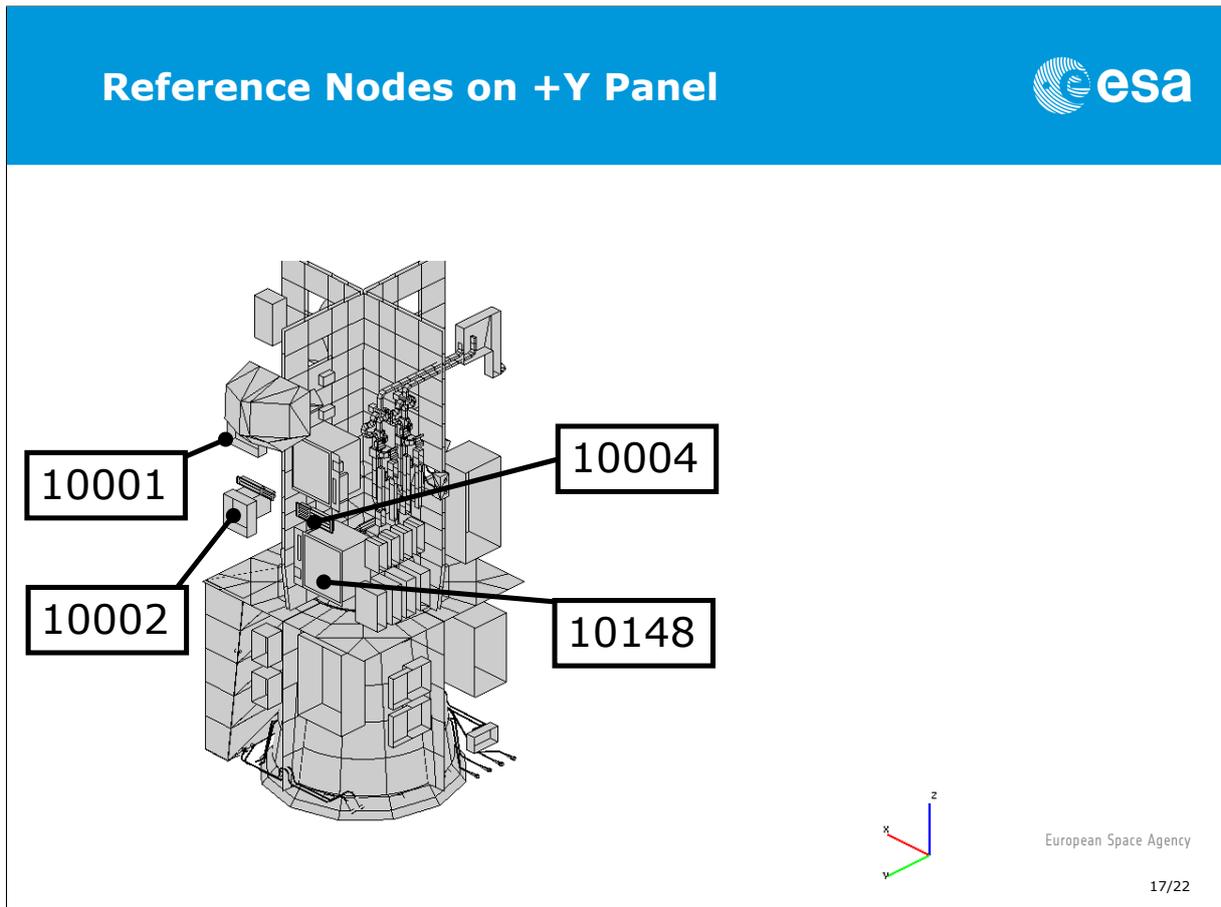
Reduction of the +Y PLM Panel

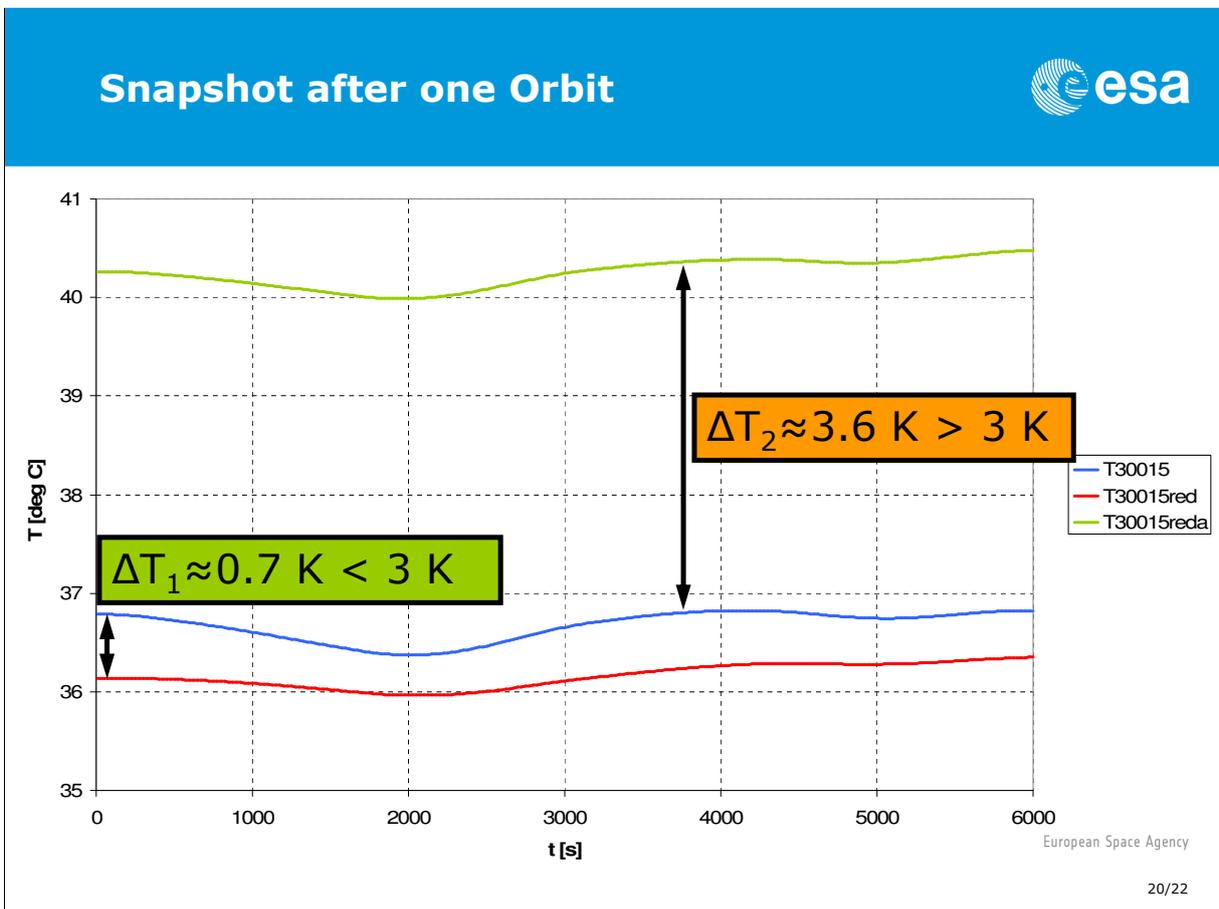
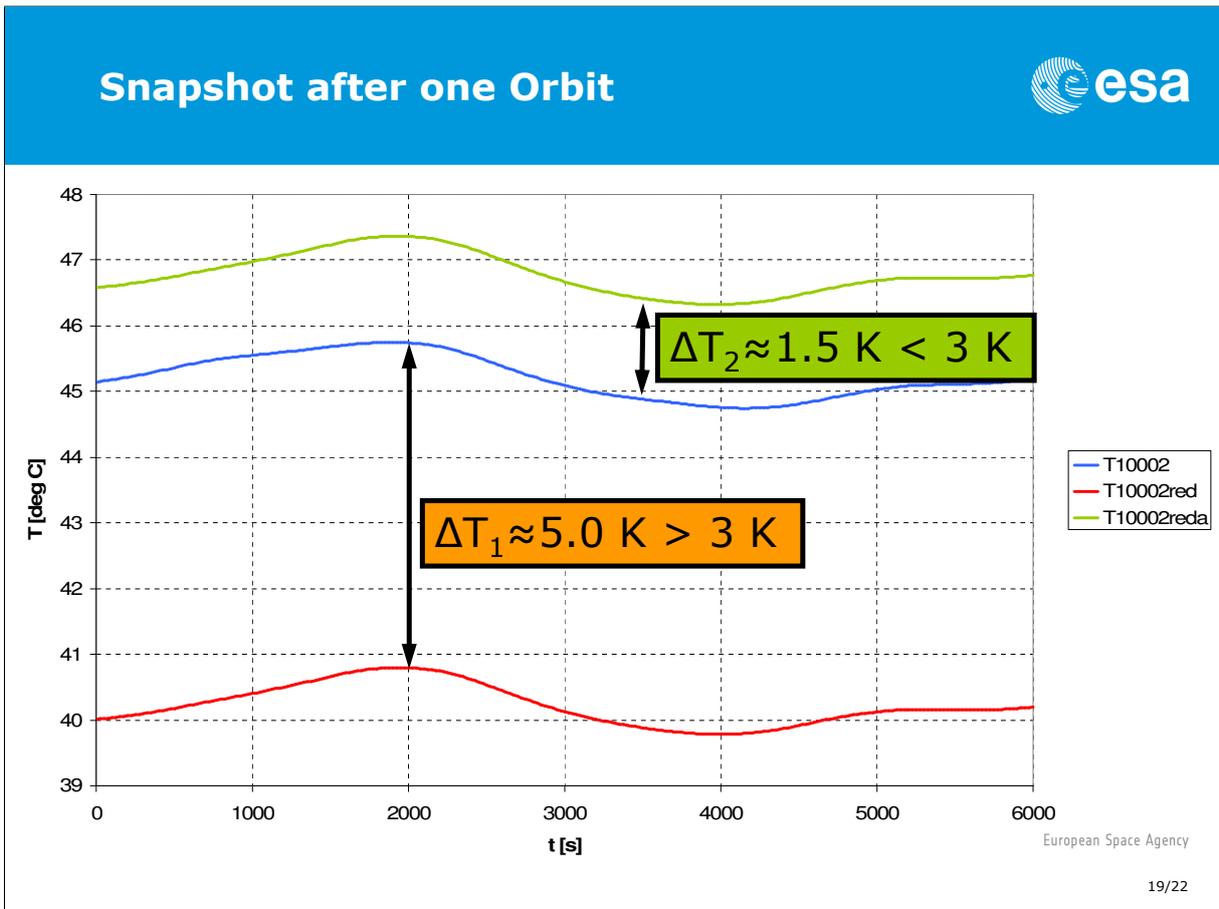


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			<div style="border: 1px solid black; padding: 5px; display: inline-block; margin-bottom: 10px;">RTMM</div> <p>44 shells 59 nodes</p>

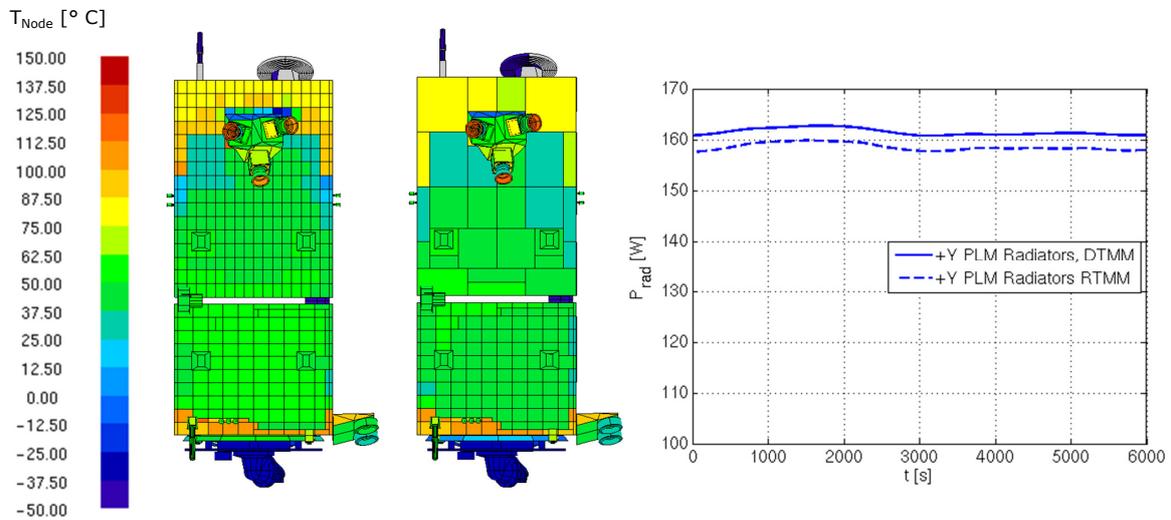
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Heat flux from radiators on +Y Panel



$$\left. \begin{aligned} W_{rad,DTMM} &= 968.9 \text{ kJ} \\ W_{rad,RTMM} &= 951.2 \text{ kJ} \end{aligned} \right\} 1.8 \% \text{ deviation}$$

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Conclusion



90 % reduction of the panels:

- ⇒ Equipment nodes within the requirements
- ⇒ Most of the reduced structural parts are within the requirements; Min/Max-values deviate more than 5 K
- ⇒ Deviations of heat flux to deep space is negligible low
- ⇒ Heater power deviates more than 5 % from the detailed model
- ⇒ Time- or temperature dependencies cannot be handled by the TMRT
 - ⇒ But can be handled manually
- ⇒ *TMRT has a great potential for strong reductions*
- ⇒ *In many cases the reduction is much more than just applying the TMRT on the DTMM*
 - ⇒ *Effort of reduction can be decreased if the DTMM was designed to be reduced*

...any Questions?

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