



Modelado térmico de un satélite básico

Contenido

Crear un modelo térmico matemático de un satélite sencillo.

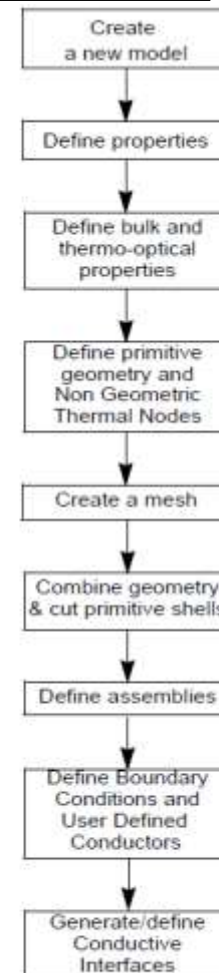
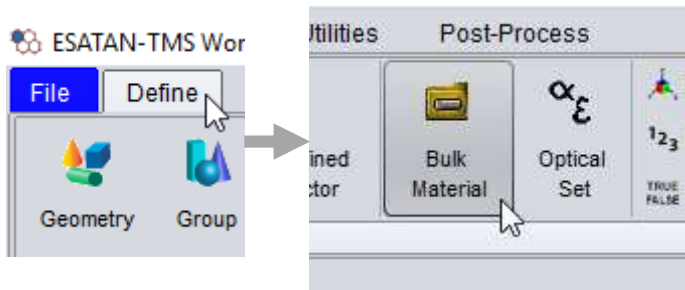


Figure 3-1 Flowchart of the geometric modelling process

Ref. ESATAN-TMS Workbench user manual

1. Definición de materiales y propiedades termo-ópticas

- Definir los materiales (Bulk): introduciendo nombre, densidad, calor específico y conductividad en unidades del S.I.



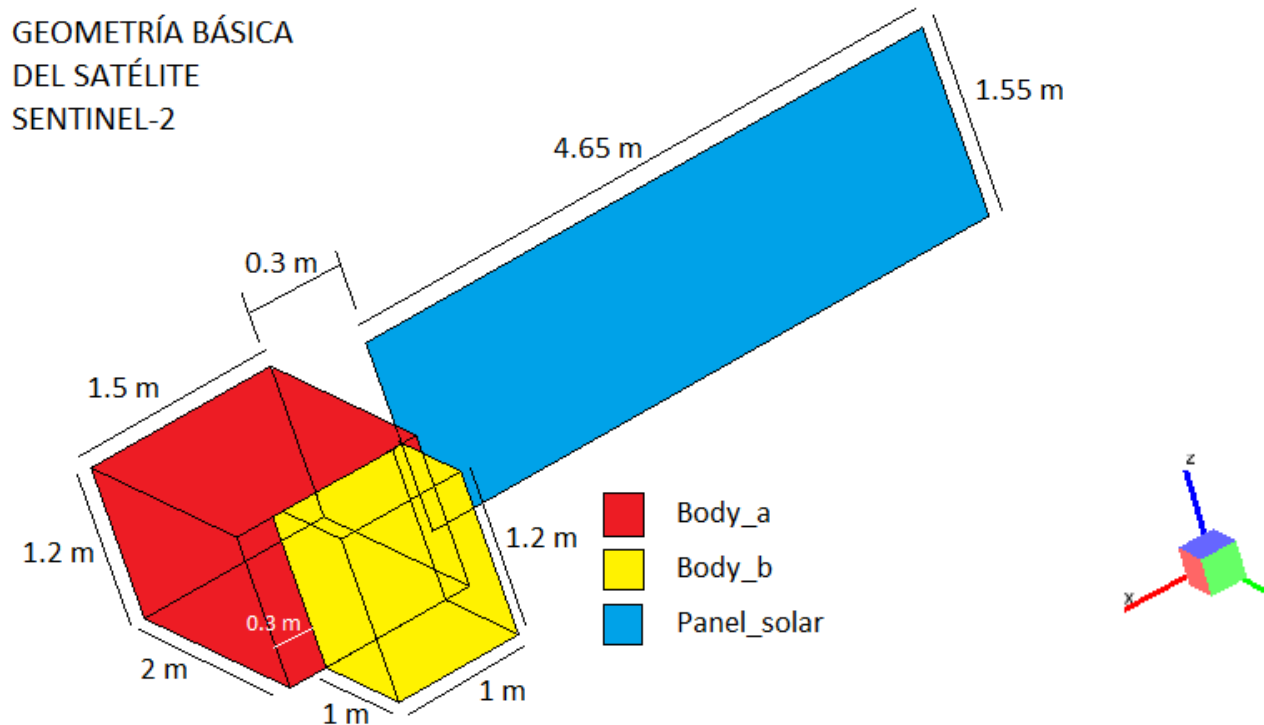
Bulk	Density (kg/m ³)	Specific Heat (J/kgK)	Conductivity (W/mK)
Al_6061	2700	900	160
MLI_foil	300	900	0
GaAs	5300	1000	55

- Definir propiedades ópticas (Optical Set): α y ε

Optical	ε	α
Black	0.84	0.97
Low_e	0.1	0.2
Solar_Cells	0.84	0.75
Kapton	0.61	0.36

2. Construcción de la geometría

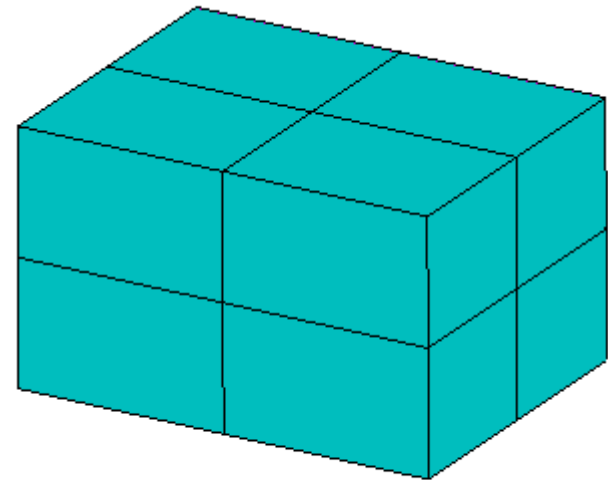
- Se construyen los tres elementos básicos de la figura con distintas estrategias



► Body_a

Definición de la geometría

Property	Value
Geometry Name	Body_a
Shape	Box
Defined By	Parameters
height (m)	1.2
xmax (m)	1.5
ymax (m)	2.0



- **Body_a** Se introduce el mallado, las propiedades de cada cara, el material y el espesor

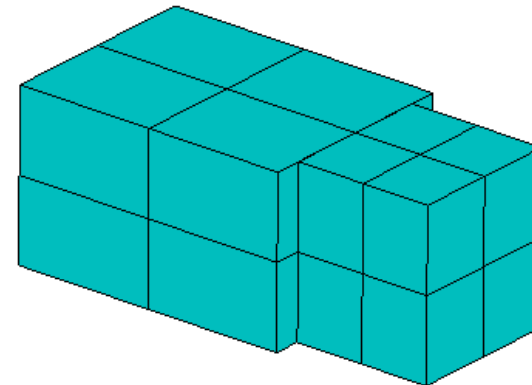
Property	Value
Nº of faces direction 1	2
Nº of faces direction 2	2
Nº of faces direction 3	2
Surface 1	
Label	Body_a_MLI
Optical	Low_e
Surface 2	
Label	Body_a_int
Optical	Black

Property	Value
Composition	DUAL
S1 – Material	MLI_Foil
S1 – Thickness	0.0005
S2 – Material	Al_6061
S2 – Thickness	0.002
Through Conductance	
Calculation Type	EFFECTIVE
Emittance	0.03

► Body_b

Definición de la geometría

Property	Value
Geometry Name	Body_b
Shape	Box
Defined By	Parameters
height (m)	1.2
xmax (m)	1.0
ymax (m)	1.0
Tansformation	
X Distance (m)	0.25
Y Distance (m)	2.001



- **Body_b** Se introduce el mallado, las propiedades de cada cara, el material y el espesor

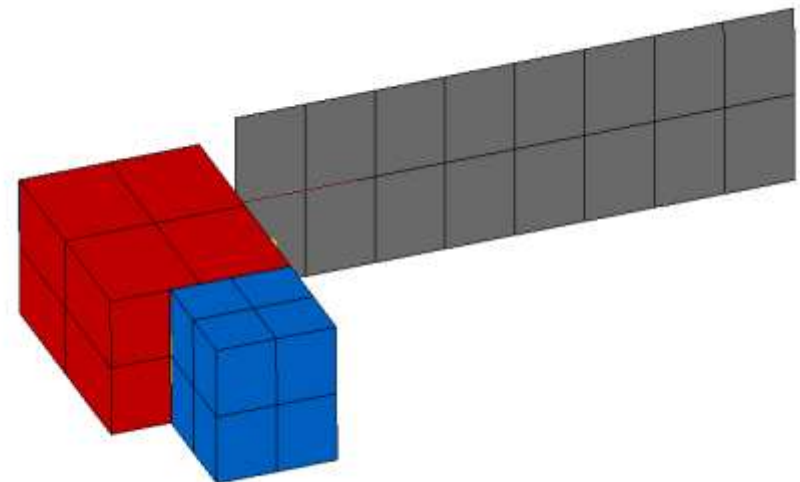
Property	Value
Nº of faces direction 1	2
Nº of faces direction 2	2
Nº of faces direction 3	2
Surface 1	
Label	Body_b_MLI
Optical	Low_e
Surface 2	
Label	Body_b_int
Optical	Black

Property	Value
Composition	DUAL
S1 – Material	MLI_Foil
S1 – Thickness	0.0005
S2 – Material	Al_6061
S2 – Thickness	0.002
Through Conductance	
Calculation Type	EFFECTIVE
Emittance	0.03

► Solar Panel

Property	Value
Geometry Name	Solar_Panel
Shape	Rectangle
xmax (m)	4.65
ymax (m)	1.55
Tansformation	
X Angle (deg)	90
X Distance (m)	-4.95
Z Distance (m)	-0.175

Definición de la geometría



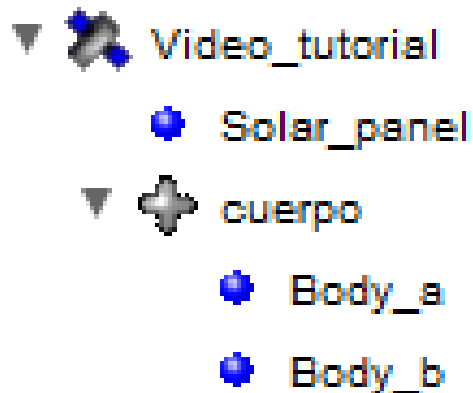
► Solar Panel

Property	Value
Nº of faces direction 1	8
Nº of faces direction 2	2
Surface 1	
Label	Solar_Panel_Support
Optical	Kapton
Surface 2	
Label	Solar_Panel_Cells
Optical	Solar_Cells

Property	Value
Composition	DUAL
S1 – Material	Al_6061
S1 – Thickness	0.001
S2 – Material	GaAs
S2 – Thickness	0.001
Through Conductance	
Calculation Type	BULK

3. Agrupación y movimiento del panel

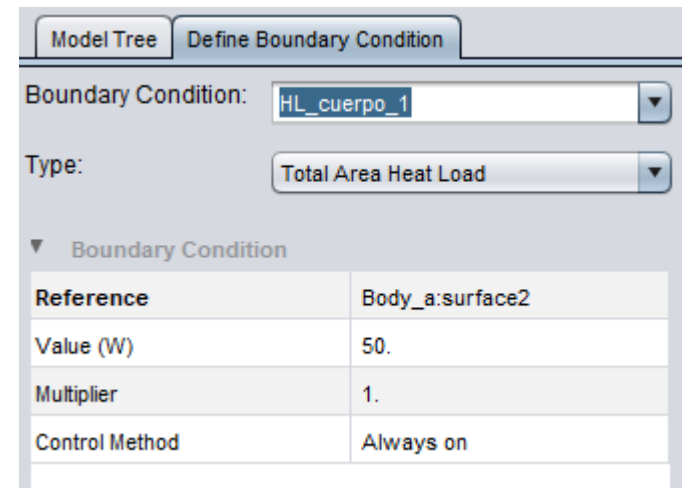
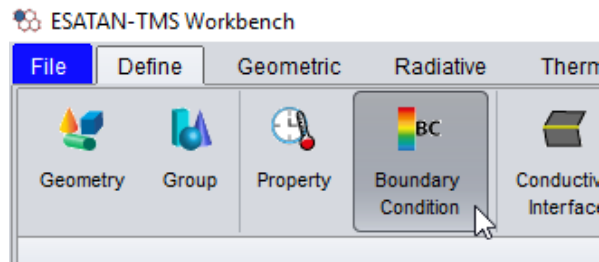
- Agrupar shells para formar estructura jerárquica del modelo



Orientation:	True Sun
▼ Symbol Information	
Reference Component	cuerpo
Moving Component	Solar_panel
▼ Assembly Axis	
Rotation Axis	[1., 0., 0.]
Rotation Axis Origin	[-0.3, 0., 0.6]
Use Coordinate Shift	<input type="checkbox"/>
▼ Automatic Pointing	
Pointing Vector	[0., 1., 0.]
Minimum Rotation Angle (...)	0.
Maximum Rotation Angle (...)	360.
Bisecting Pointing	<input type="checkbox"/>
Focus Point	[0., 0., 0.]

4. Condiciones de contorno

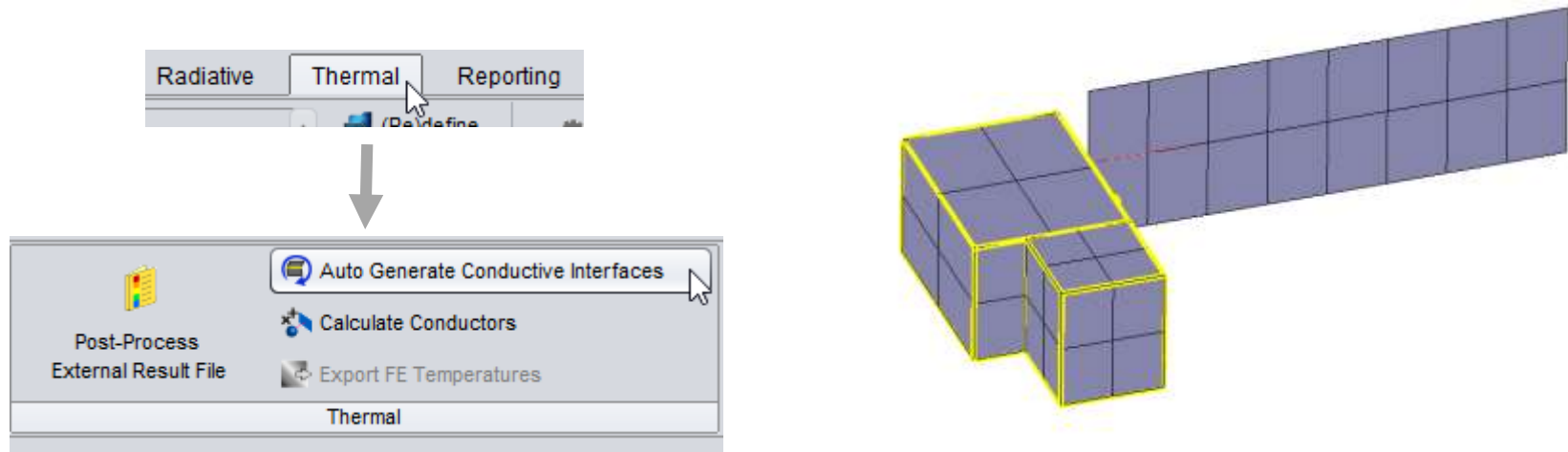
- ▶ Introducir las potencias disipadas por los equipos mediante interfaz gráfica



- ▶ Se reparten 75 W entre los dos nodos interiores: 50 W en el cuerpo_1 y 25 W en cuerpo_2.

5. Generación de interfaces conductivas

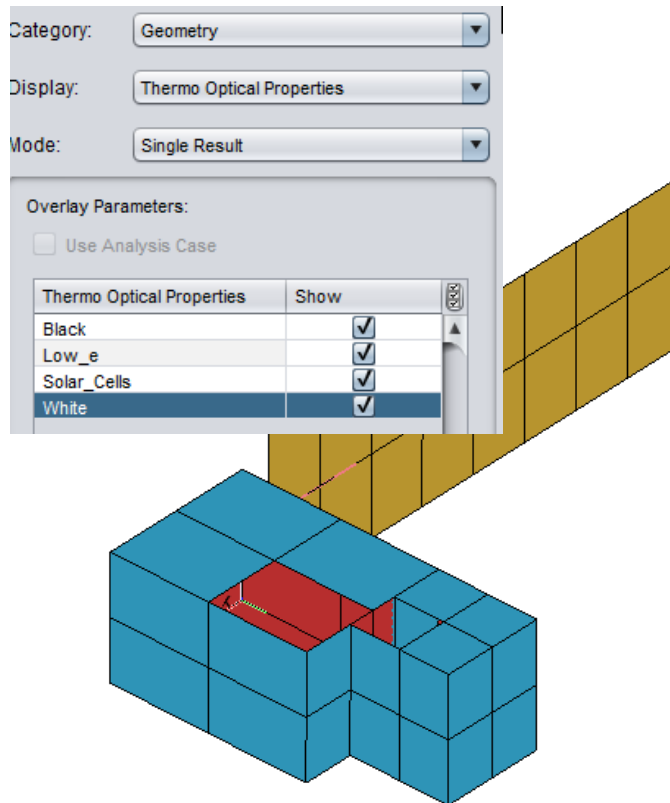
- ▶ Se generan aquellas que ESATAN detecta automáticamente.



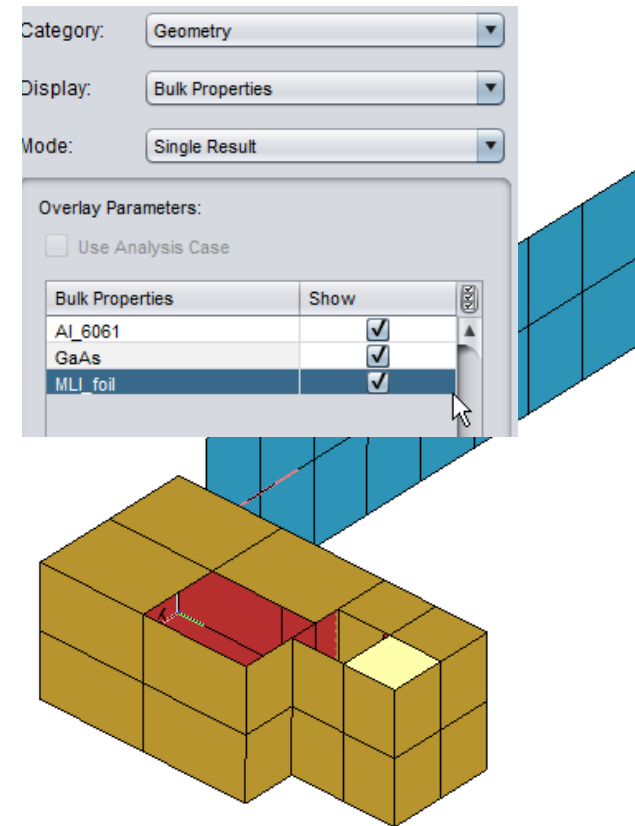
- ▶ Se cambian todas las interfaces a tipo 'Fused' (por defecto)

6. Comprobación del modelo

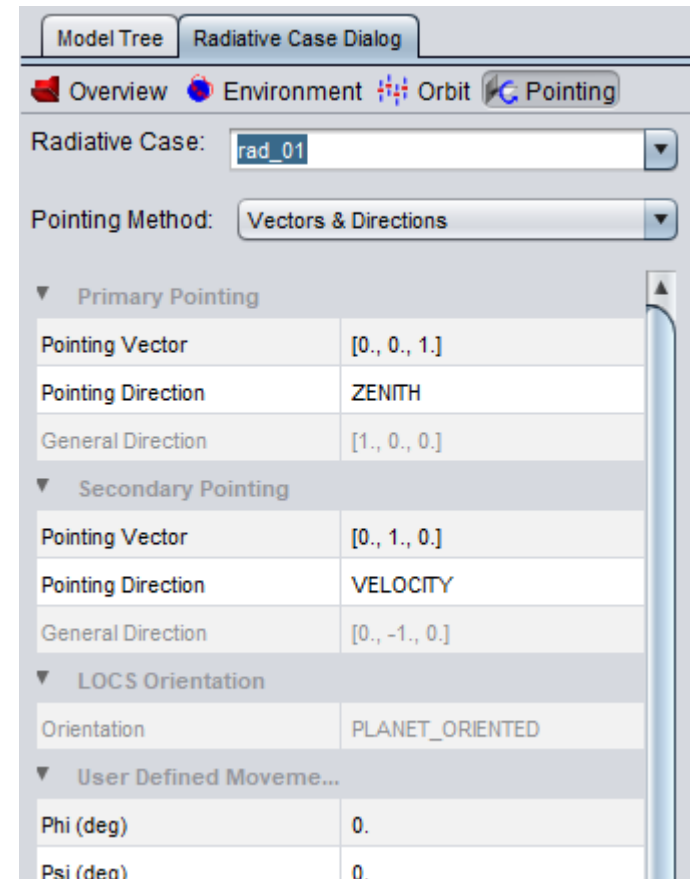
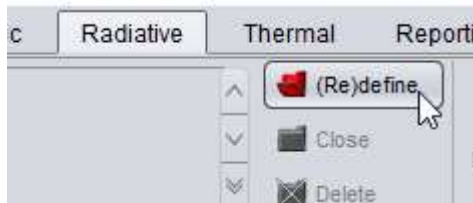
Propiedades termo-ópticas



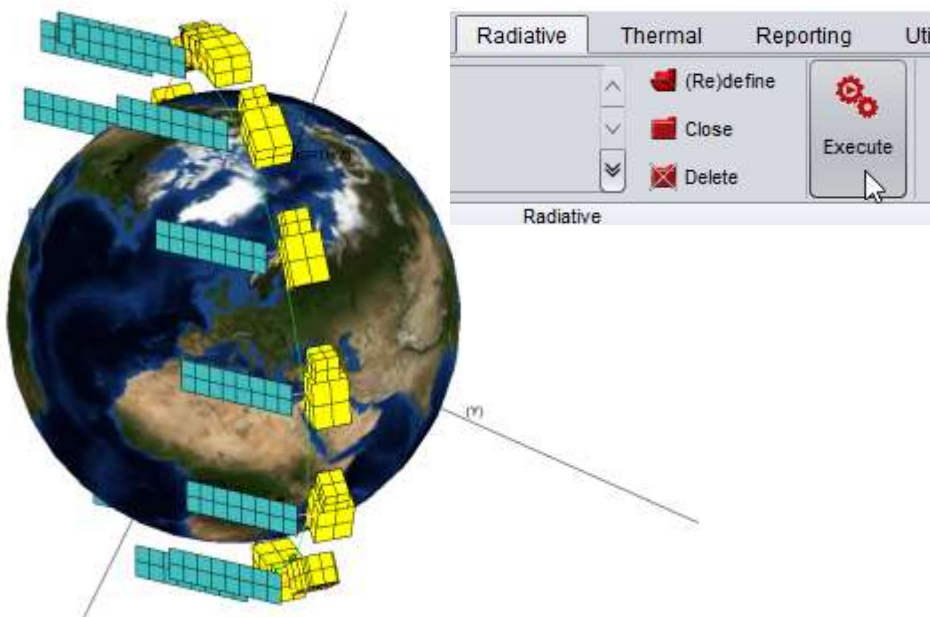
Materiales



7. Caso radiativo



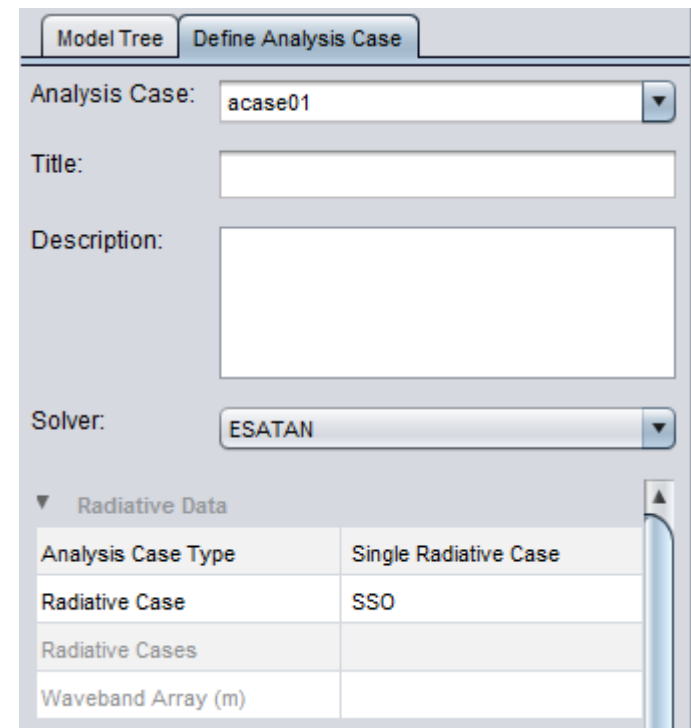
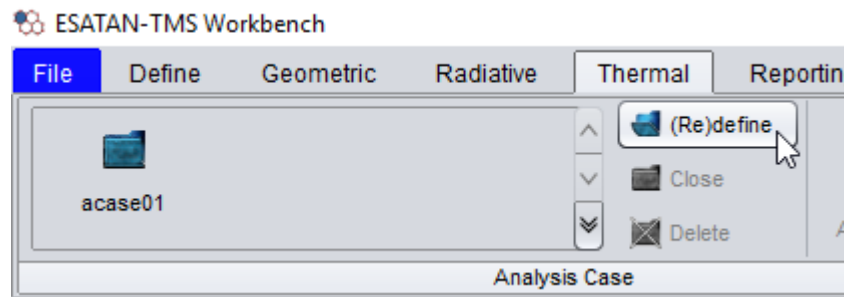
- Se ejecuta para obtener los factores de vista, GRs y las cargas del Sol (QS), Albedo (QA) e infrarrojo terrestre (QE).



Model Tree		Execute Dialog	
▼ Accuracy Parameters			
Control Method	FIXED_RAYS		
Ray (VF/REF) Total Cutoff	0.005		
Ray (VF/REF) Non-Critical	1,000		
Ray (VF/REF) Normal	10,000		
Ray (VF/REF) Critical	100,000		
Ray Density Non-Critical	10,000		
Ray Density Normal	100,000		
Ray Density Critical	1,000,000		
Line Accuracy Non-Critical	0.1		
Line Accuracy Normal	0.03		
Line Accuracy Critical	0.001		
Line Confidence Non-Critical	0.95		
Line Confidence Normal	0.95		
Line Confidence Critical	0.95		
Ray (HF) Non-Critical	1,000		
Ray (HF) Normal	10,000		
Ray (HF) Critical	100,000		
▼ Raytracing Parameters			
Seed	1,000		
Extinct Threshold	0.001		
▼ Calculations			
VF Geometric	<input checked="" type="checkbox"/>		
REF MCRT	<input checked="" type="checkbox"/>		
Solar Direct Flux	<input checked="" type="checkbox"/>		
Solar Absorbed MCRT	<input checked="" type="checkbox"/>		
Planet & Albedo Direct Flux	<input checked="" type="checkbox"/>		
Planet & Albedo Abs MCRT	<input checked="" type="checkbox"/>		
UV Emission Direct Flux	<input type="checkbox"/>		
UV Emission Absorbed Flux	<input type="checkbox"/>		


8. Caso de análisis

- ▶ Se selecciona el radiative case deseado: SS0



- Se define el esquema de solución (transitorio en este caso) y se añade al bloque de ejecución.

Control Logic

Solution Control	Default	
Output Calls	Default	
Generate Min-Max Data	<input type="checkbox"/>	

Solution Control Dialog

Analysis: Thermal ☒ Thermo-hydraulic ☐

Solution: Transient

Method: Crank-Nicolson

Routine Name

Routine Name	SLCRNC
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Transient Definition

Solution start time (s)	0
Solution end time (s)	6,009.794454904987
Output interval (s)	600.9794454904987

Iteration Control

Max number of iterations	500
Convergence criterion (K)	0.01
Damping factor	1

Timestep Control

Initial time step (s)	10
Max change in temp per time step (...)	10,000,000,000
Minimum time step (s)	0
Maximum time step (s)	10,000,000,000
Temperature rate of change conv ...	10,000,000,000
Arith. node cut-off	0

Steady Cyclic Solution

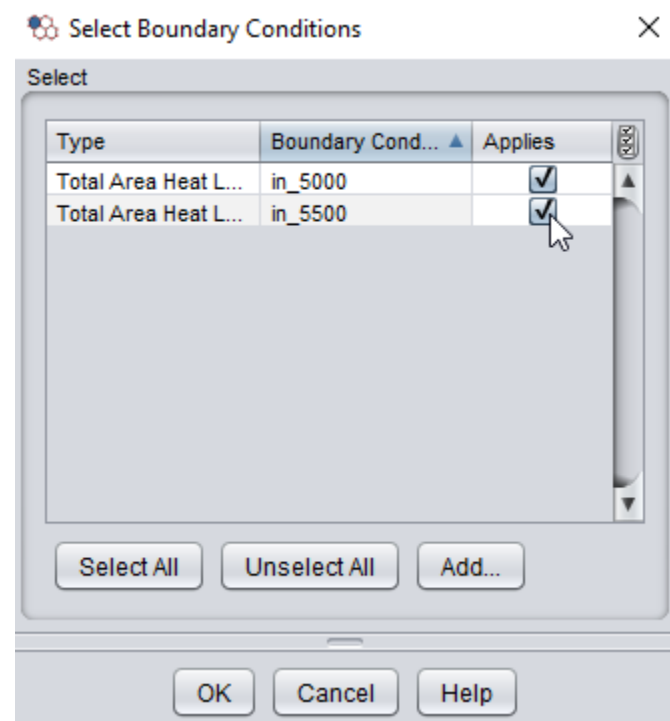
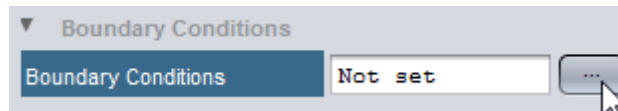
Cyclic solution	<input checked="" type="checkbox"/>
Temp convergence criterion (K)	0.1
RoC convergence criterion	0.01
Max number of cycles	500
Period of cycles (s)	6,009.794454904987
Nodes for conv criteria	
Output type required	NONE

Add at Cursor

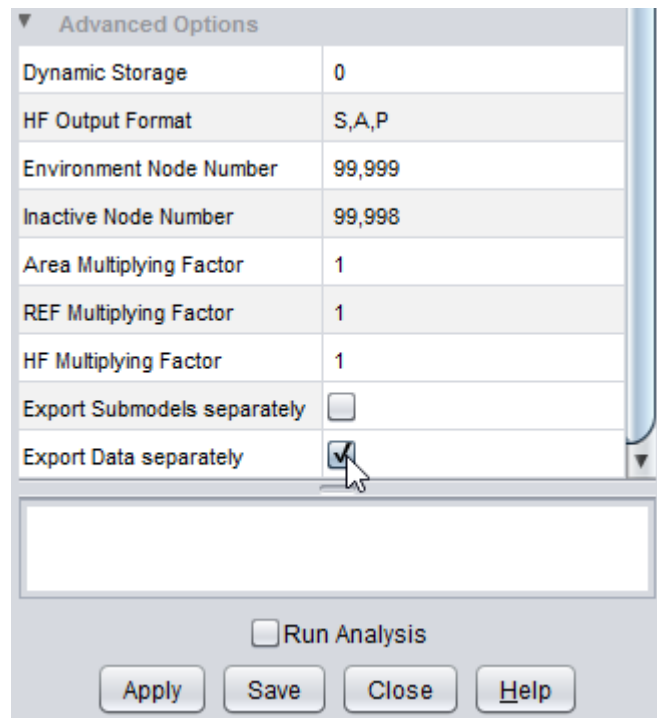
```

C
  TIMEND=6009.794454904987
  OUTINT=600.9794454904987
  NLOOP=500
  RELXCA=0.01
  DTIMEI=10.0
  CALL SOLCYC('SLCRNC',0.1D0,0.01D0,6009.794454904987,500,10.0,10000000000.0,10000000000.0,0.0)
C
  CALL SLCRNC
C
  
```

- ▶ Se seleccionan las condiciones de contorno, que en este caso son las potencias disipadas.



- Se pide que incluya los los flujos solar, albedo e infrarrojo y se pone número a los nodos de contorno (ambiente e inactivo).



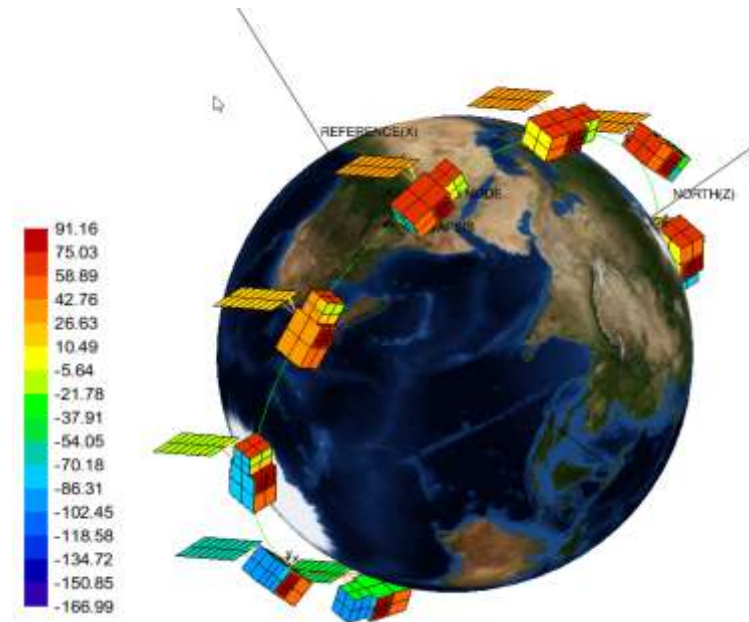
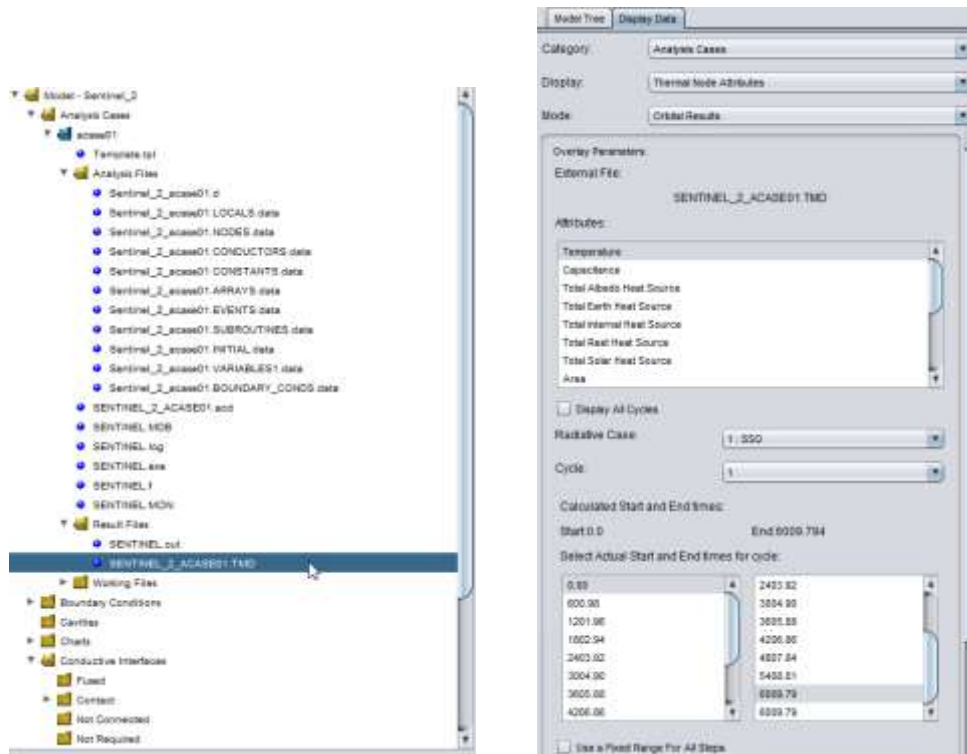
The image shows a software dialog box titled "Advanced Options". It contains a table of settings with the following values:

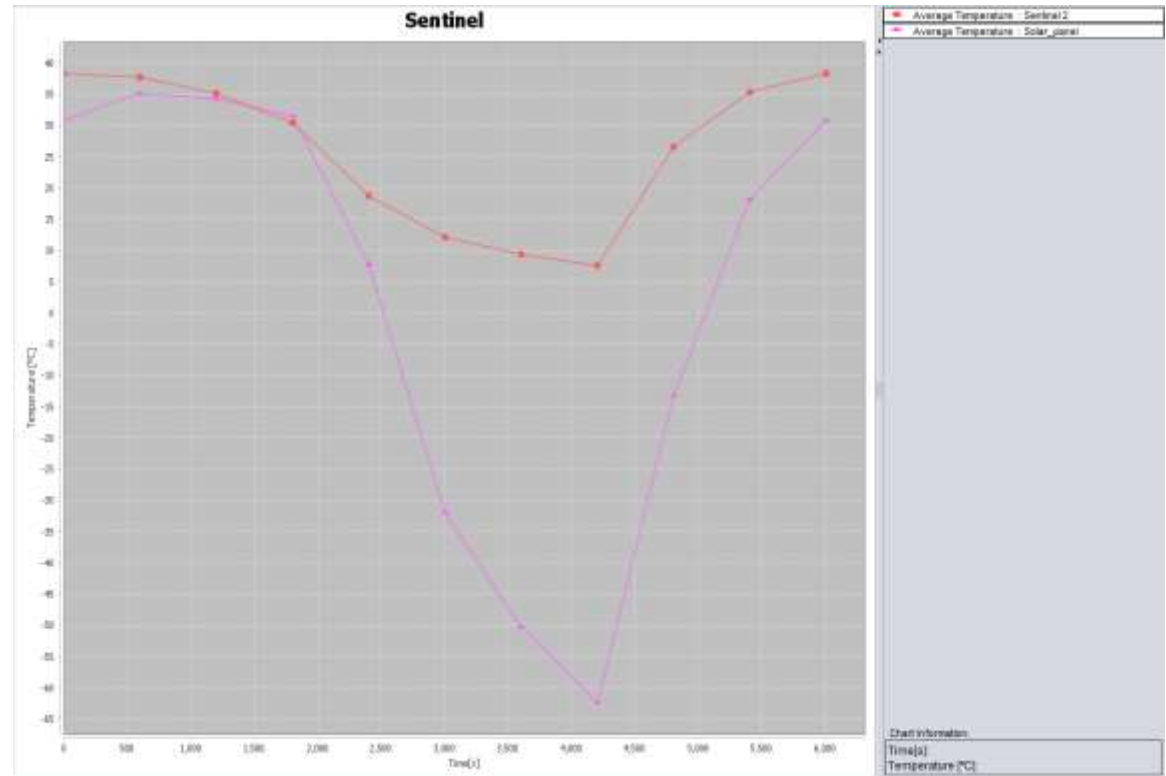
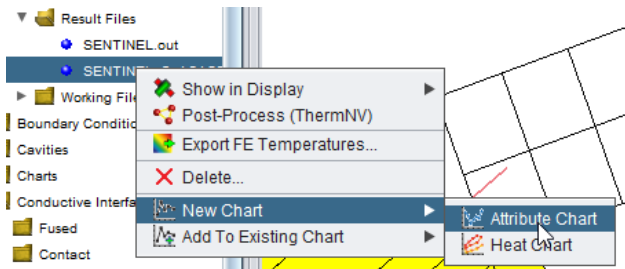
Option	Value
Dynamic Storage	0
HF Output Format	S,A,P
Environment Node Number	99,999
Inactive Node Number	99,998
Area Multiplying Factor	1
REF Multiplying Factor	1
HF Multiplying Factor	1
Export Submodels separately	<input type="checkbox"/>
Export Data separately	<input checked="" type="checkbox"/>

Below the table is a large empty text area. At the bottom of the dialog, there is a checkbox labeled "Run Analysis" which is currently unchecked. Below this are four buttons: "Apply", "Save", "Close", and "Help". A mouse cursor is pointing at the "Export Data separately" checkbox.

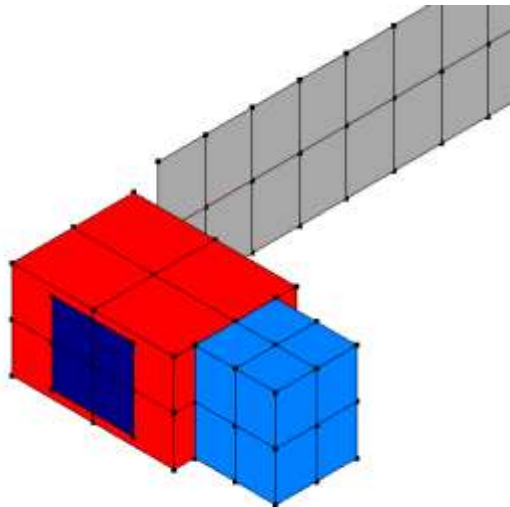
9. Visualización de resultados

- ▶ Los resultados se guardan en un archivo TMD y se configura su visualización haciendo doble click en el archivo.





10. Radiador



Geometry Name: **Radiator**

Shape: **Rectangle**

Geometry Type: ☒ Shell ☐ Solid

Defined By: **Parameters**

Params

xmax (m)	1.0
ymax (m)	1.0
height (m)	0.0
xmin (m)	0.0
ymin (m)	0.0

Transform

Method	X Y Z
X Angle (deg)	0
Y Angle (deg)	90
Z Angle (deg)	0
X Distance (m)	1.501
Y Distance (m)	0.5
Z Distance (m)	1.1
Application Order	XR, YR, ZR, XT, YT, ZT

Cutting

Cutting Sense	Keep Outside
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Surface 1

Label	Radiator
Activity	Active
Radiative Criticality	NORMAL
Submodel name	
Base Node Number	18,500
Node Increment in Directi...	1
Node Increment in Directi...	
Optical Coating	White
Colour	DARK_BLUE

Surface 2

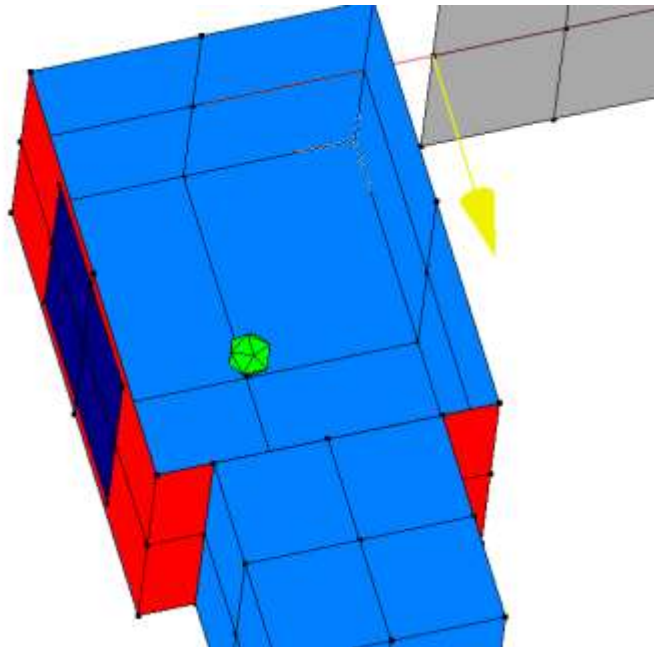
Label	Radiator
Activity	Conductive
Radiative Criticality	NORMAL
Submodel name	
Base Node Number	18,000
Node Increment in Directi...	1
Node Increment in Directi...	
Optical Coating	White
Colour	BLUE_CYAN

Shell Material

Composition	SINGLE
Material	Aluminio
Thickness (m)	0.002

Surface 1 - Material

11. Nodo no geométrico



Geometric Properties Diagrams

Geometry Name: inner_2

Shape: Non Geometric Thermal Node

Geometry Type: ☒ Shell ☐ Solid

Defined By: Parameters

Parameters

Origin: [0.75, 1.0, 0.2]

Radius (m): 0.1

Thermal Node

Node Number: 5500

Model Name:

Label:

Capacitance

Method: VALUE

Volume (m³): 0.0

Bulk Material:

Value (J/K): 20.0

Node Colour

Outside: GREEN

Inside: GREEN

Transform

Method: X Y Z

X Angle (deg): 0

Y Angle (deg): 0

Z Angle (deg): 0

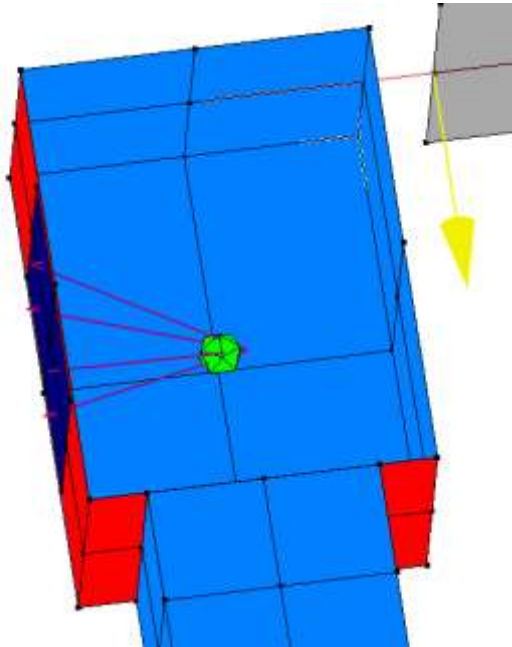
X Distance (m): 0

Y Distance (m): 0

Value (J/K)

This PROPERTY or REAL parameter is used to specify the capacitance of the node. If specified (and

12. Acoplamiento conductivo



Model Tree		Define Non-Geometric Conductor	
Conductor:	Inner_2_Rad_1		
Type:	Conductive		
▼ Connection			
Source Reference	Inner_2		
Destination Reference	Radiator: face5		
▼ Definition			
Method	VALUE		
Value (W/K)	0.125		
▼ Conductive Factors			
Conductivity (W/m.K)	0.0		
Shape Factor Method	VALUE		
Shape Factor	0		
Cross Sectional Area (m2)	0		
Path Length (m)	0		