Appendix L

Improve thermal analysis process with Systema V4 and Python

Alexandre Darrau
(Airbus Defence and Space, France)

Abstract

When performing analyses, thermal engineers follow a methodology to ensure results quality and traceability. However, some checking or/and post-processing operations are still manually done or are performed later in the analysis process, leading to error and time wasting.
The purpose of this presentation is to introduce how the Airbus Defence & Space Thermal Engineering department in Toulouse is working to overcome these difficulties using new Systema V4 functions and Python technology. An example for each thermal analysis stage is going to be presented to illustrate.

Improve thermal analyses process with SystemaV4 + Python

Alexandre Darrau, Jean-Baptiste Bernaudin
Thermal Engineering - Airbus Defence & Space – Thermal Team

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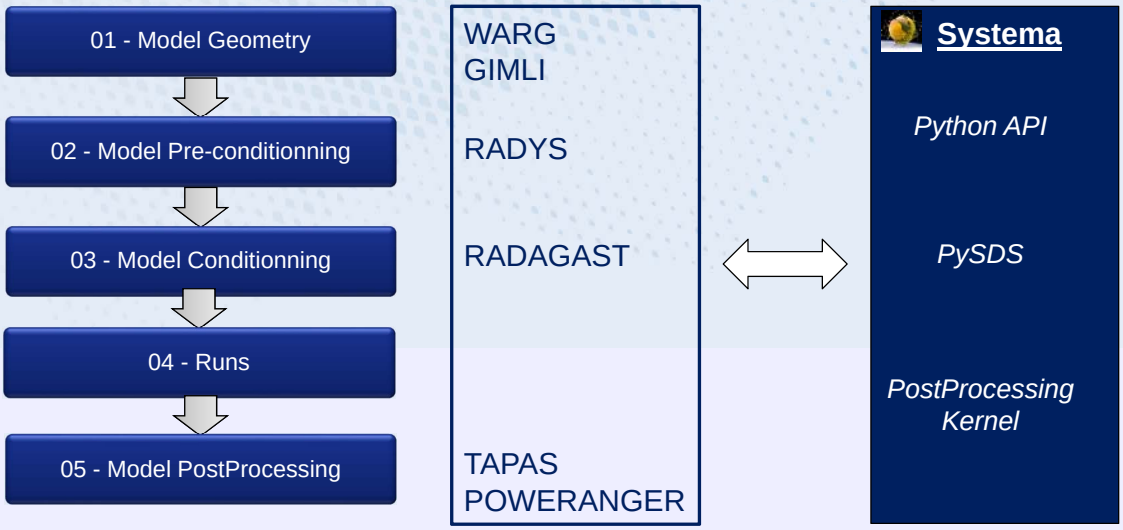
PLAN

- Objectives & Strategy
- Application on Thermal analysis process



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Objectives & Strategy (1/2)

Objectives: Support thermal engineer !

- **Prevent** time wasting + manual operations ➔ **Automatisation (helper tools…)**
- **Ensure** thermal analysis quality ➔ **Check at each analysis stage**
- **Remove** industrials softwares borders ➔ **Object-Oriented + Modular approach**
- **Standardize** data presentations.

Automatic tools will **never** replace engineer thermal but **only optimize** its time !

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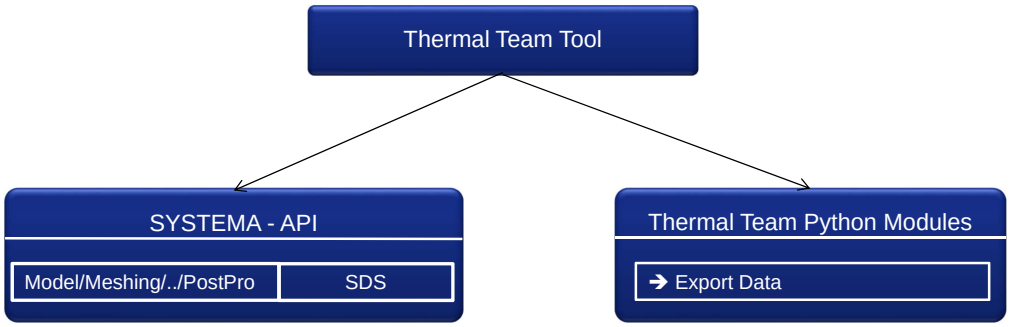
Objectives & Strategy (2/2)

Strategy:

- Set global methodology to pinpoint thermal engineer needs
- For each need, define a method to apply.
- When a tool is needed:
  - Use object oriented approach
  - Split data treatment from format
  - Category: modelling helper tool, checker, analysis tool



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PLAN

- Objectives & Strategy
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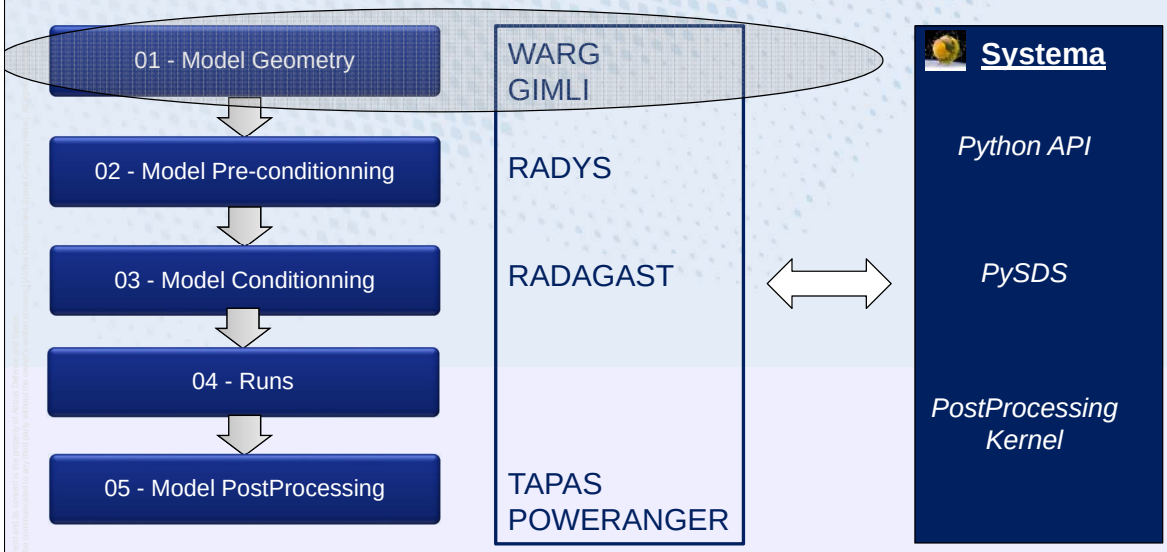

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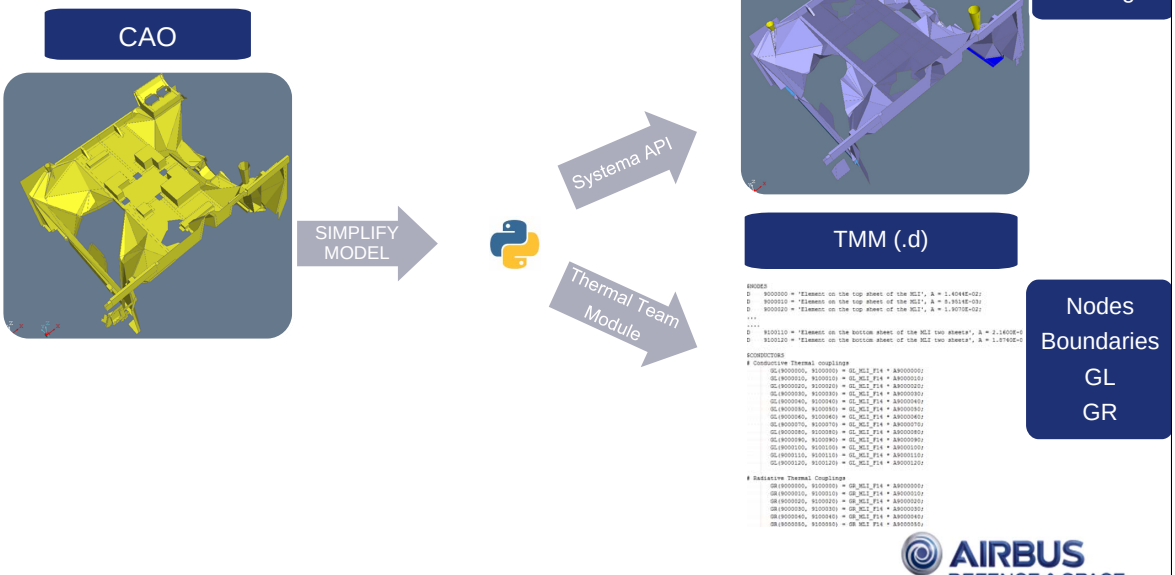
Model Geometry

GIMLI: Generation MLI

- Modelling Helper Tool
- Automatize MLI GMM and TMM model generation



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Model Geometry

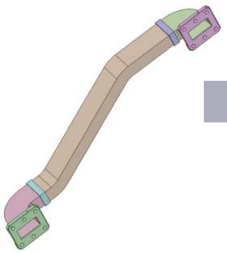
WARG: Waveguide Rapid Generator

- Modelling Helper Tool:

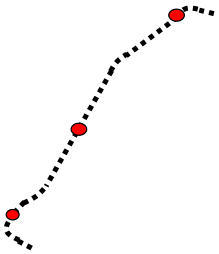
➔ *Automatize waveguide GMM and TMM model generation*

CAO

Neutral Line + Support Pos



EXTRACT DATA



Systema API

Thermal Team Module

GMM

Mesh coatings

TMM (.d)

Nodes Boundaries GL

```
$NODES
D     121940 = 'WG entreeCAO, standard portion', A = 1.1576E-03;
D     121941 = 'WG entreeCAO, standard portion', A = 1.4027E-03;
D     121942 = 'WG entreeCAO, standard portion', A = 9.4460E-04;
D     121943 = 'WG entreeCAO, standard portion', A = 9.4460E-04;
D     121944 = 'WG entreeCAO, standard portion', A = 1.7292E-03;
D     121945 = 'WG entreeCAO, standard portion', A = 1.1117E-03;
D     121946 = 'WG entreeCAO, standard portion', A = 1.1117E-03;
D     121947 = 'WG entreeCAO, standard portion', A = 1.1117E-03;
D     121948 = 'WG entreeCAO, standard portion', A = 1.1117E-03;
D     121949 = 'WG entreeCAO, standard portion', A = 6.1750E-04;
D     121950 = 'WG entreeCAO, standard portion', A = 1.1853E-03;
D     121951 = 'WG entreeCAO, standard portion', A = 1.1743E-03;
D     121952 = 'WG entreeCAO, standard portion', A = 6.2462E-04;

$CONDUCTORS
# Conductive Thermal couplings
      GL(-1, 121940) = conductivity_entreeCAO * section_entreeCAO * 1e6 / (0.019705 / 2);
      GL(-1, 121952) = conductivity_entreeCAO * section_entreeCAO * 1e6 / (0.010350 / 2);
      GL(121941, 121940) = conductivity_entreeCAO * section_entreeCAO * 1e6 / ((0.019708 + 0.023506) / 2);
      GL(121942, 121941) = conductivity_entreeCAO * section_entreeCAO * 1e6 / ((0.023506 + 0.015652) / 2);
      GL(121943, 121942) = conductivity_entreeCAO * section_entreeCAO * 1e6 / ((0.015652 + 0.015652) / 2);
```

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PLAN

- Objectives & Strategy
- Application on Thermal analysis process

01 - Model Geometry

02 - Model Pre-conditionning

03 - Model Conditionning

04 - Runs

05 - Model PostProcessing

WARG
GIMLI

RADYS

RADAGAST

TAPAS
POWERANGER

Systema

Python API

PySDS

PostProcessing Kernel

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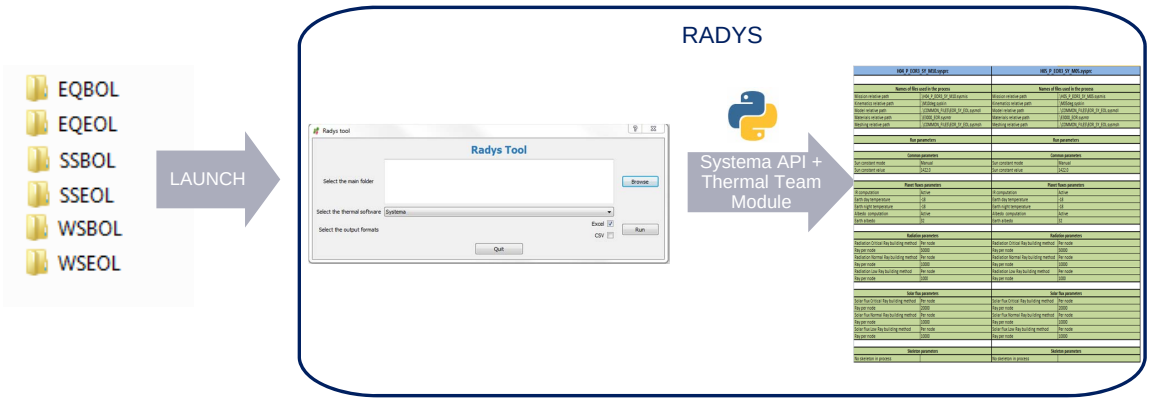
Model Preconditionning

RADYS: Radiative synthesis

- Checker tool : *Check radiative cases data and generate report before run!*



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Model Preconditionning

RADYS: Radiative synthesis

- Checker tool : *Check radiative cases data and generate report before run!*

Names of files used in the process		Names of files used in the process	
Mission relative path	.\H04_P_EOR3_SY_M10.sysmis	Mission relative path	.\H05_P_EOR3_SY_M05.sysmis
Kinematics relative path	.\M10deg.syskin	Kinematics relative path	.\M05deg.syskin
Model relative path	..\COMMON_FILES\EOR_SY_EOL.sysmdl	Model relative path	..\COMMON_FILES\EOR_SY_EOL.sysmdl
Materials relative path	.\E3000_EOR.sysmtr	Materials relative path	.\E3000_EOR.sysmtr
Meshing relative path	..\COMMON_FILES\EOR_SY_EOL.sysmsh	Meshing relative path	..\COMMON_FILES\EOR_SY_EOL.sysmsh
Run parameters		**Run parameters**	
Common parameters		**Common parameters**	
Sun constant mode	Manual	Sun constant mode	Manual
Sun constant value	1422.0	Sun constant value	1422.0
Planet fluxes parameters		**Planet fluxes parameters**	
IR computation	Active	IR computation	Active
Earth day temperature	-18	Earth day temperature	-18
Earth night temperature	-18	Earth night temperature	-18
Albedo computation	Active	Albedo computation	Active
Earth albedo	32	Earth albedo	32
Radiation parameters		**Radiation parameters**	
Radiation Critical Ray building method	Per node	Radiation Critical Ray building method	Per node
Ray per node	50000	Ray per node	50000
Radiation Normal Ray building method	Per node	Radiation Normal Ray building method	Per node
Ray per node	10000	Ray per node	10000
Radiation Low Ray building method	Per node	Radiation Low Ray building method	Per node
Ray per node	1000	Ray per node	1000
Solar flux parameters		**Solar flux parameters**	
Solar flux Critical Ray building method	Per node	Solar flux Critical Ray building method	Per node
Ray per node	20000	Ray per node	20000
Solar flux Normal Ray building method	Per node	Solar flux Normal Ray building method	Per node
Ray per node	10000	Ray per node	10000
Solar flux Low Ray building method	Per node	Solar flux Low Ray building method	Per node
Ray per node	10000	Ray per node	10000
Skeleton parameters		**Skeleton parameters**	
No skeleton in process		No skeleton in process	

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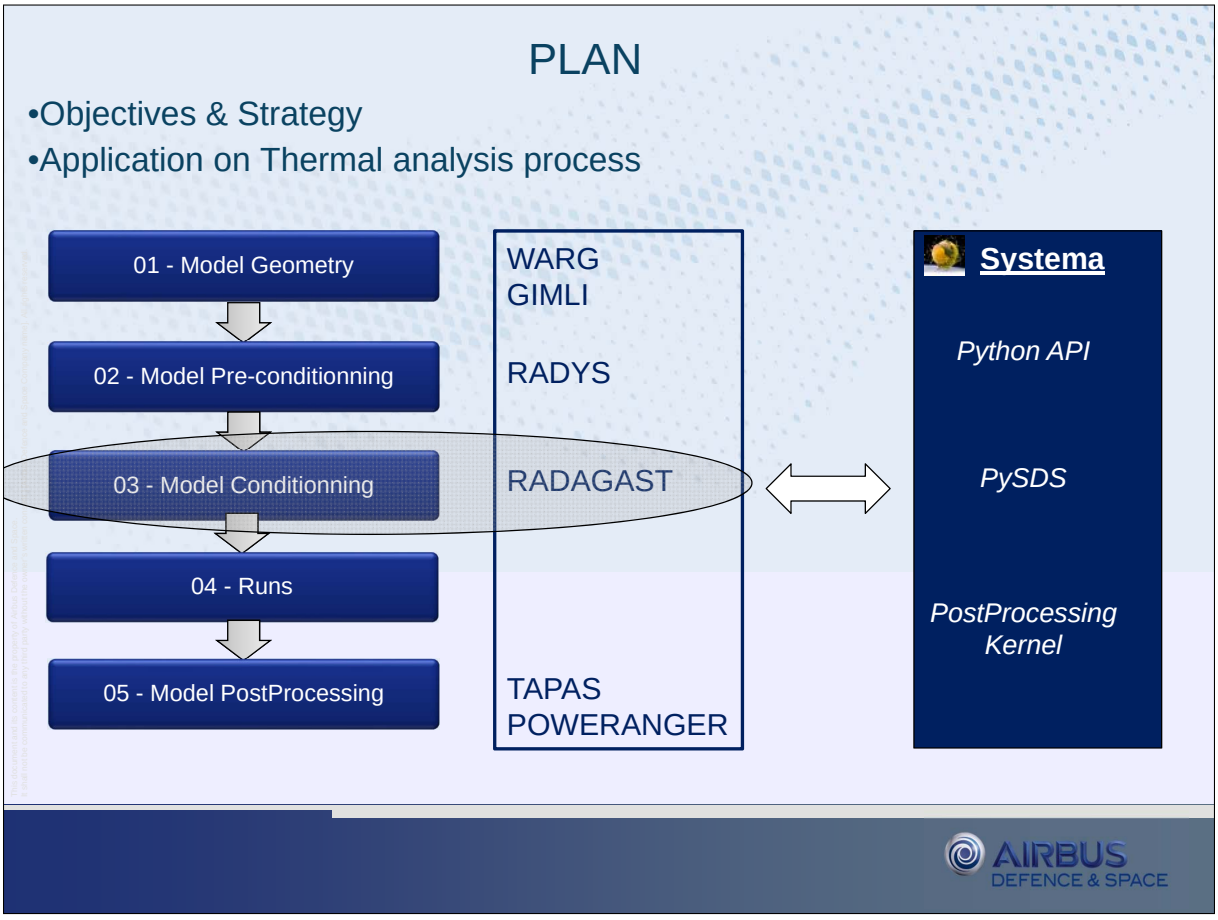
PLAN
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01 - Model Geometry
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WARG
GIMLI
RADYS
RADAGAST
TAPAS
POWERANGER
Systema
Python API
PySDS
PostProcessing Kernel
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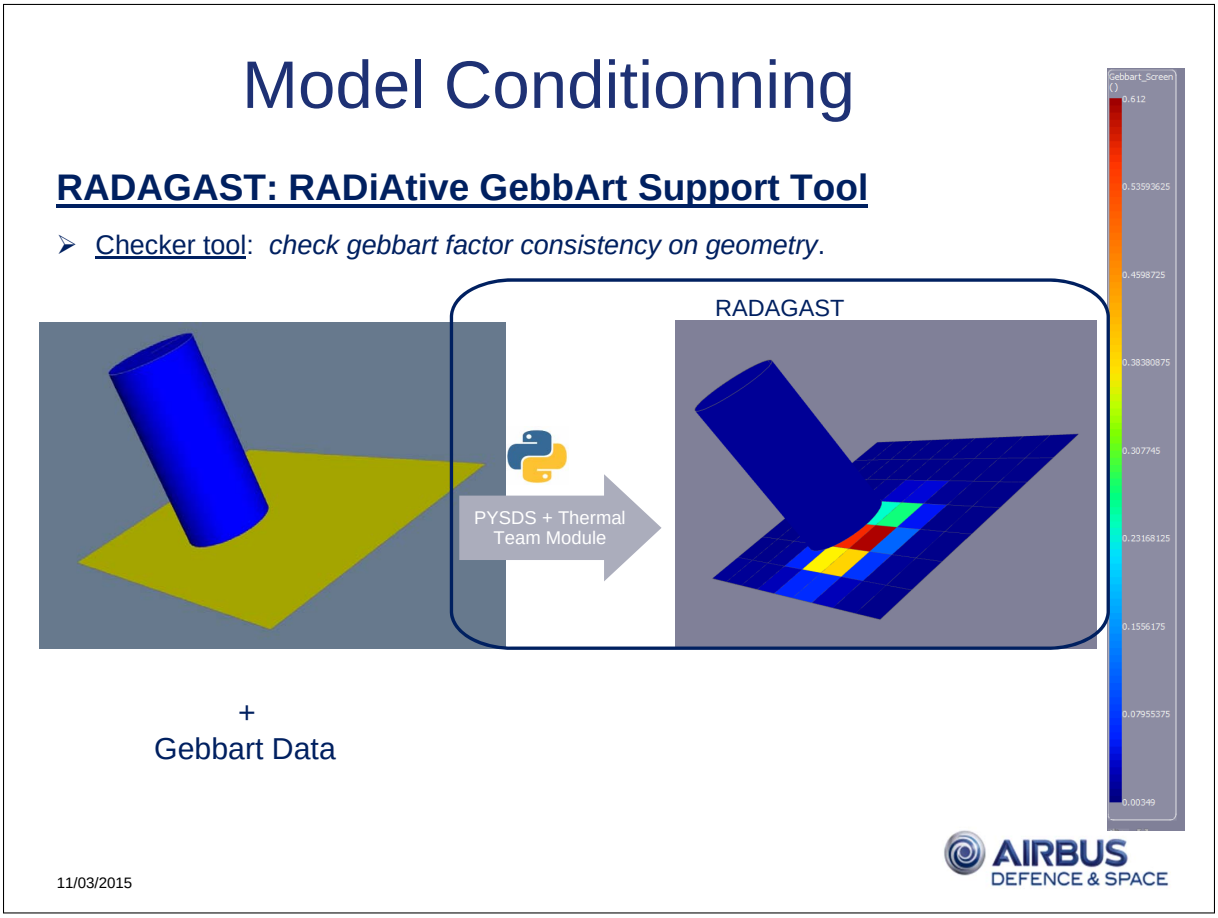
Model Conditionning
RADAGAST: RADiAtive GebbArt Support Tool
Checker tool: check gebbart factor consistency on geometry.
RADAGAST
PYSDS + Thermal Team Module
+
Gebbart Data
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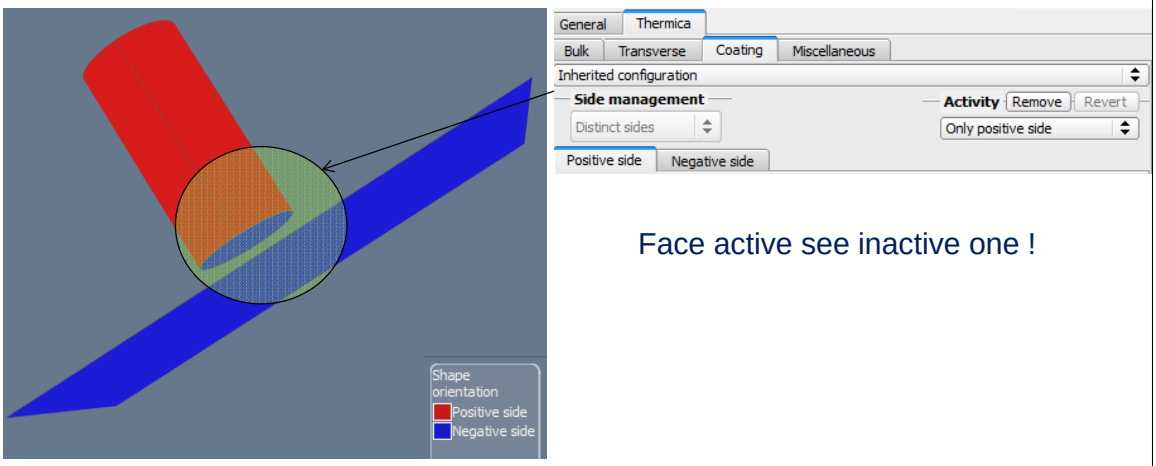
Model Conditionning

RADAGAST: RADiAtive GebbArt Support Tool

- Check gebbart factor consistency on geometry.



Face active see inactive one !

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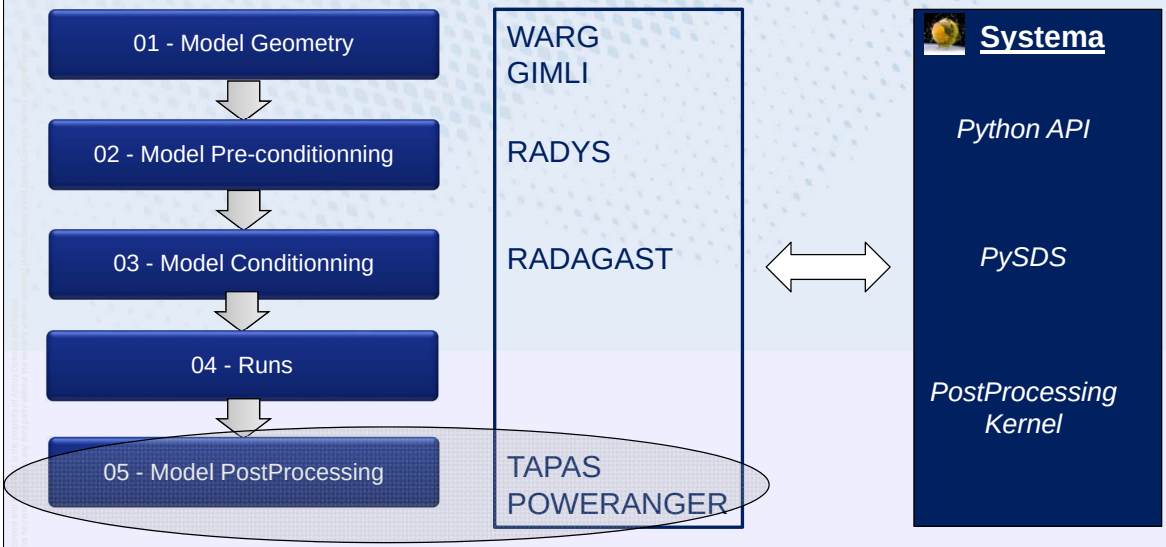
PLAN

- Objectives & Strategy
- Application on Thermal analysis process



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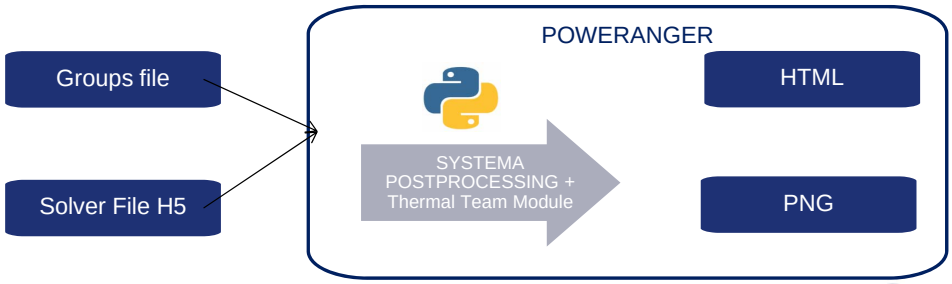
Model PostProcessing

POWERANGER: POWEr Range GEneratoR

- Tool for thermal analysis
  - *Perform power budget on groups **after** thermisol runs.*
  - *Steady-State and Transient cases on selected times.*
  - *Taking into account GL,GR variations and Edges elements.*
  - *Having graphical views of power* exchanges and table synthesis.



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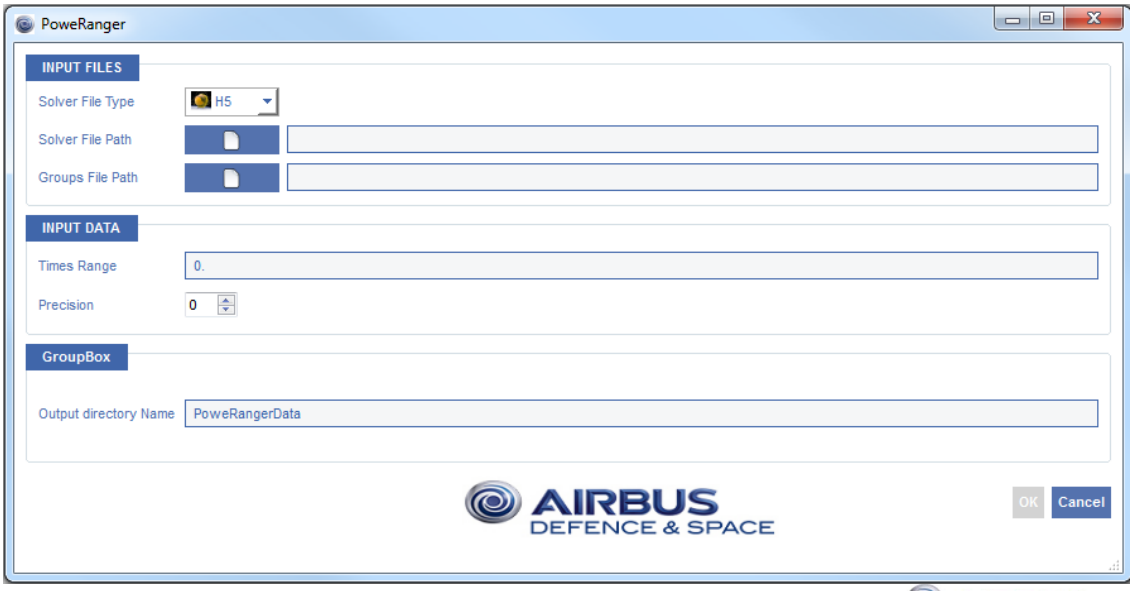
Model PostProcessing

POWERANGER: POWEr Range GEneratoR

- Tool for thermal analysis



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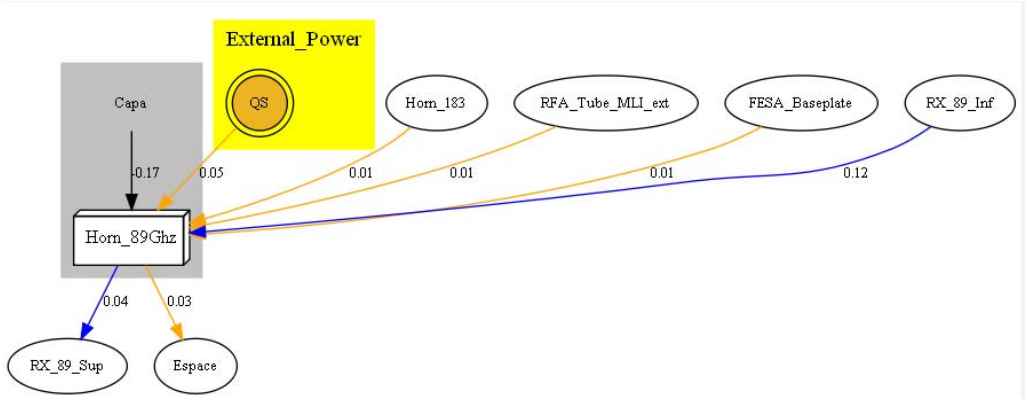
Model PostProcessing

POWERANGER: POWEr Range GEneratoR



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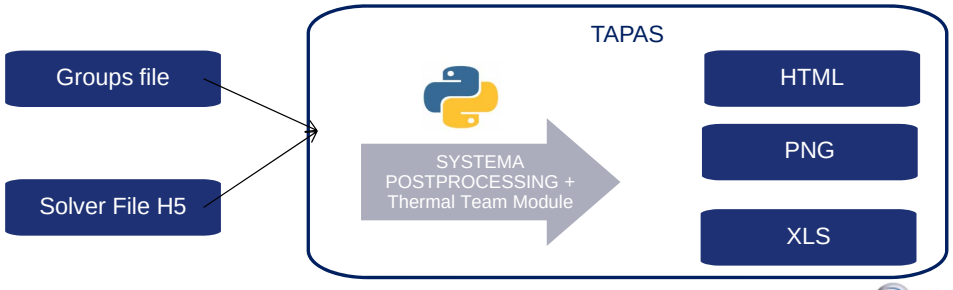
Model PostProcessing

TAPAS: Thermal Analysis PostProcessing Airbus Satellite

- Compute Tmin/max/ave/Gradients on groups **AFTER** runs
- Compute QI/QR/QS/QA/QE on groups **AFTER** runs
- Compute Mass Balance **AFTER** runs + Manage Equipement status
- Generate automatically charts (2d and horizontal bars), 3dviews
- Generate automatically Excel + HTML thermal reports



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Model PostProcessing

TAPAS:

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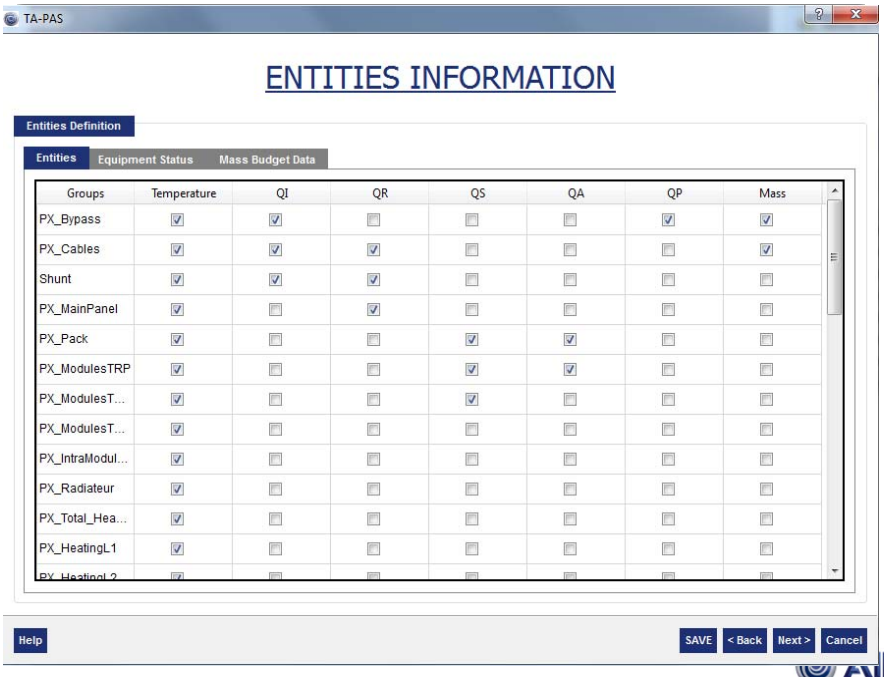
Model PostProcessing

TAPAS:



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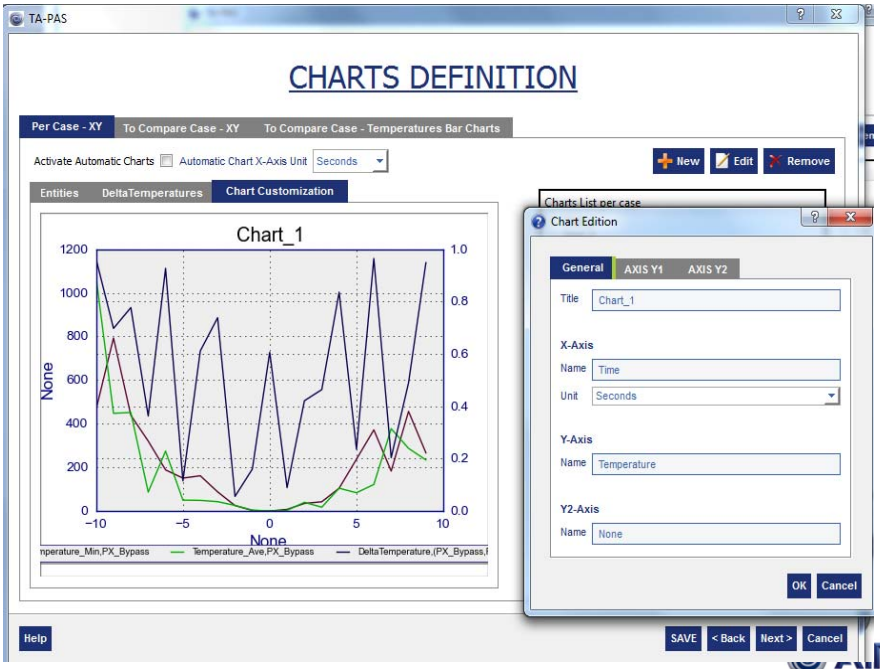
Model PostProcessing

TAPAS:



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Model PostProcessing

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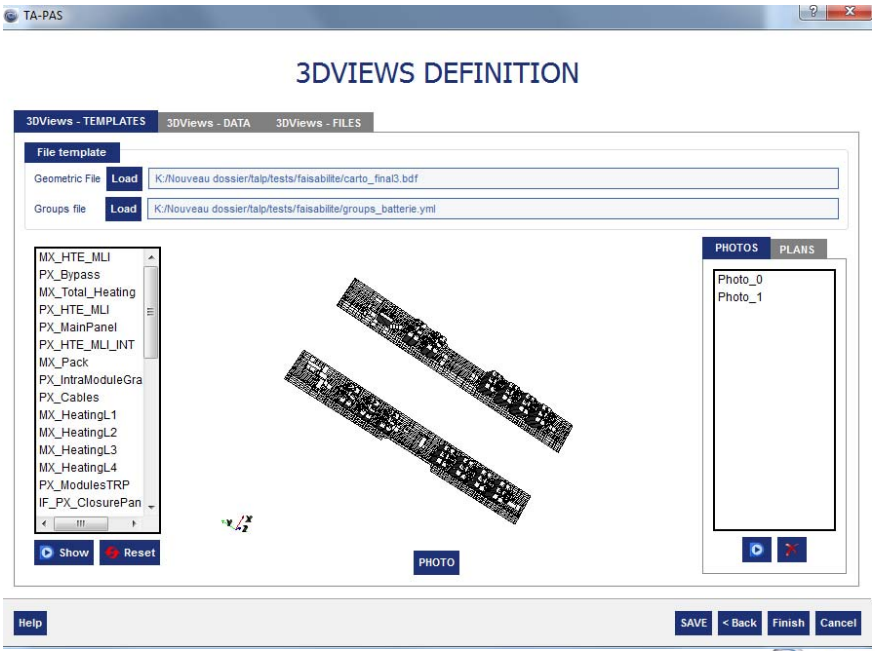

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TA-PAS

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HTML

PROJECT NAME

CASE 1

AUTO_CHARTS CHARTS 3DVIEWS

THERMAL CASES
- ALL_CASES
- CASE 1
- CASE 2

PREDICTION TEMPERATURES

EQEOL	UNITS STATUS	COLD LIMITS		PREDICTED	CALCULATED	CALCULATED	PREDICTED	HOT LIMITS		MARGINS	
		NO-OPERATING [C]	DESIGN [C]	TMIN [C]	TMIN [C]	TMAX [C]	TMAX [C]	DESIGN [C]	NO-OPERATING [C]	COLD [C]	HOT [C]
HeatPipes											
PX_HP20600		-100.0	-5.0(*)	11.5	12.5	27.7	28.7	5.0	100.0	111.5	23.7
PX_HP20700		-100.0	-5.0	11.1	12.1	26.9	27.9	5.0	100.0	111.1	22.9
PX_HP20800		-100.0	-5.0	11.5	12.5	27.8	28.8	5.0	100.0	111.5	23.8
MLI											
MX_HTE_MLI		-100.0	-5.0	-168.7	-167.7	450.0	451.0	5.0	100.0	-68.7	446.0
MX_HTE_MLI_INT		-100.0	-5.0	11.0	12.0	60.9	61.9	5.0	100.0	111.0	56.9
PX_HTE_MLI		-100.0	-5.0	-180.0	-179.0	450.0	451.0	5.0	100.0	-80.0	446.0
PX_HTE_MLI_INT		-100.0	-5.0	10.8	11.8	43.9	44.9	5.0	100.0	110.8	39.9
Others											
Bass		-100.0	-5.0	-14.6	-13.6	37.7	38.7	5.0	100.0	85.4	33.7
Structure											
PX_MainPanel		-100.0	-5.0	5.3	6.3	33.8	34.8	5.0	100.0	105.3	29.8
PX_Radiateur		-100.0	-5.0	-11.9	-10.9	27.2	28.2	5.0	100.0	88.1	23.2

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TA-PAS

	A	B	C	D	E	F	G	N	O	P	Q	R
1	EQEOL	CERTAINT		UNITS STATUS	COLD LIMITS		PREDICTED	PREDICTED	HOT LIMITS		MARGINS	
2												
3		Operating										
4		MIN	MAX		No-Operating [C]	Design [C]	TMIN [C]	TMAX [C]	Design [C]	No-Operating [C]	Cold [C]	Hot [C]
5	HeatPipes											
6	PX_HP20600	-1	1		-100	-5	11,5	28,7	5	100	111,5	23,7
7	PX_HP20700	-1	1		-100	-5	11,1	27,9	5	100	111,1	22,9
8	PX_HP20800	-1	1		-100	-5	11,5	28,8	5	100	111,5	23,8
9	MLI											
10	MX_HTE_MLI	-1	1		-100	-5	-168,7	451	5	100	-68,7	446
11	MX_HTE_MLI_INT	-1	1		-100	-5	11	61,9	5	100	111	56,9
12	PX_HTE_MLI	-1	1		-100	-5	-180	451	5	100	-80	446
13	PX_HTE_MLI_INT	-1	1		-100	-5	10,8	44,9	5	100	110,8	39,9
14	Others											
15	Bass	-1	1		-100	-5	-14,6	38,7	5	100	85,4	33,7
16	Structure											
17	PX_MainPanel	-1	1		-100	-5	5,3	34,8	5	100	105,3	29,8
18	PX_Radiateur	-1	1		-100	-5	-11,9	28,2	5	100	88,1	23,2
19	Structure_MX											
20	MX_MainPanel	-1	1		-100	-5	10,7	32,6	5	100	110,7	27,6
21	MX_Radiateur	-1	1		-100	-5	-8	27,5	5	100	92	22,5
22	Units											
23	Interpack	-1	1		-100	-5	-0,4	3,7	5	100	99,6	-1,3
24	MX_Bypass	-1	1		-100	-5	12,4	43,7	5	100	112,4	38,7
25	MX_Cables	-1	1	ON-Forced	-100	-5	12,6	74,8	5	100	17,6	69,8
26	MX_ModulesTRP	-1	1		-100	-5	13	30,6	5	100	113	25,6
27	MX_Pack	-1	1	ON	-100	-5	12,4	74,8	5	100	17,4	69,8
28	PX_Bypass	-1	1	ON	-100	-5	12,4	45,4	5	100	17,4	40,4
29	PX_Cables	-1	1	ON	-100	-5	11,9	59,7	5	100	16,9	54,7
30	PX_IntraModuleGradient	-1	1		-100	-5	-0,8	2,1	5	100	99,2	-2,9
31	PX_ModulesTRP	-1	1		-100	-5	12,9	30,8	5	100	112,9	25,8
32	PX_ModulesTRP_1CMF	-1	1		-100	-5	12,9	30,8	5	100	112,9	25,8
33	PX_ModulesTRP_2CMF	-1	1		-100	-5	12,9	30,8	5	100	112,9	25,8
34	PX_Pack	-1	1	ON	-100	-5	11,6	98,7	5	100	16,6	93,7
35	Shunt	-1	1	ON	-100	-5	12,5	98,7	5	100	17,5	93,7

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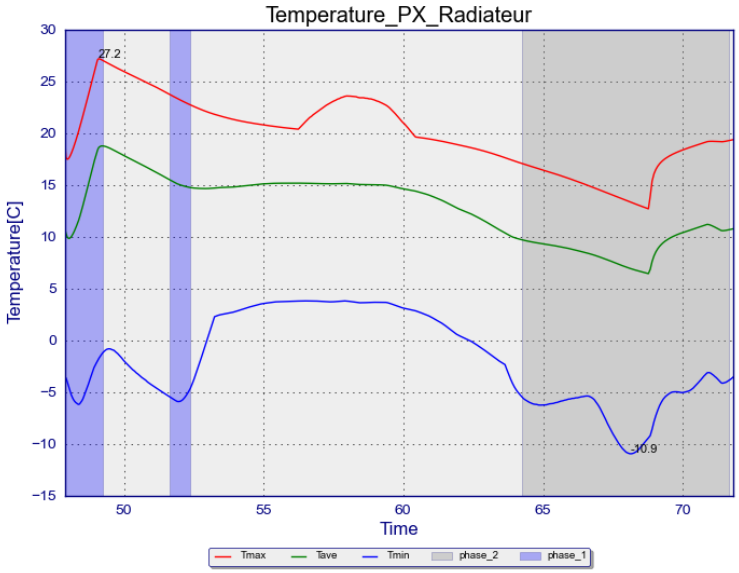

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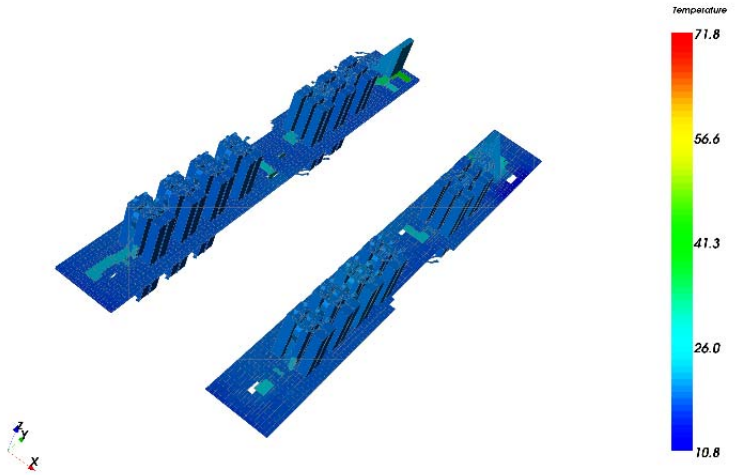

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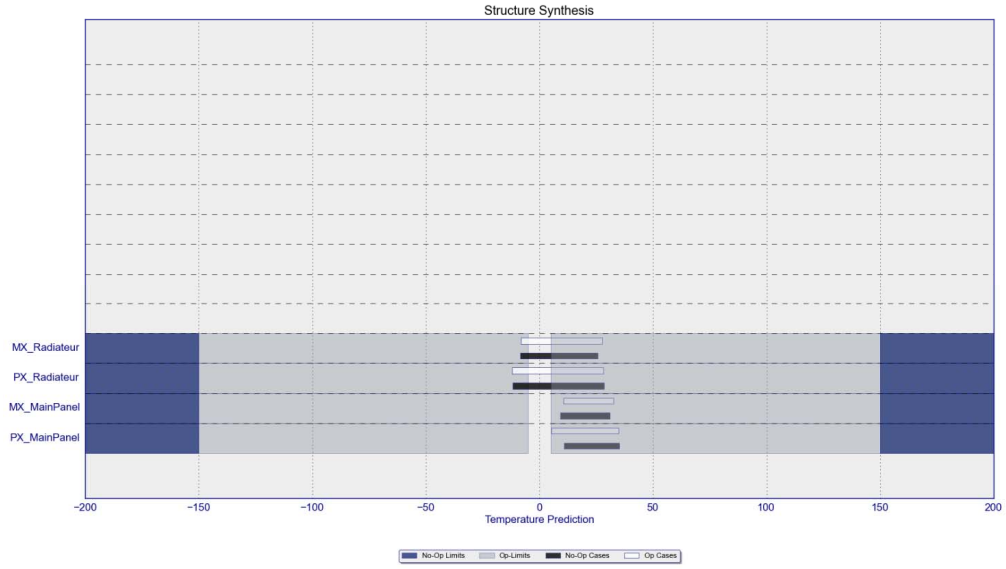

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CONCLUSIONS

- Thanks to SYSTEMA API, it is possible to:
  - *Optimize time model/meshing creations*
  - *Easily check thermal model.*
  - *Plotting user data on mesh.*
- Thanks to Python, it is possible to :
  - *Create simple tools without deep software engineering knowledege.*
  - *Wrap Systema API*
  - *Design tools with oriented object approach.*
  - *Create user friendly tools thanks to existing packages.*
- Collaboration with Systema Team to improve existing functions and create new ones:
  - *Materials data to be integrated in API*
  - *Implementing new box in postprocessing library*
  - *….*

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QUESTIONS ?

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