Appendix O

Assessment of stochastic methods for the thermal design of a telecom satellite

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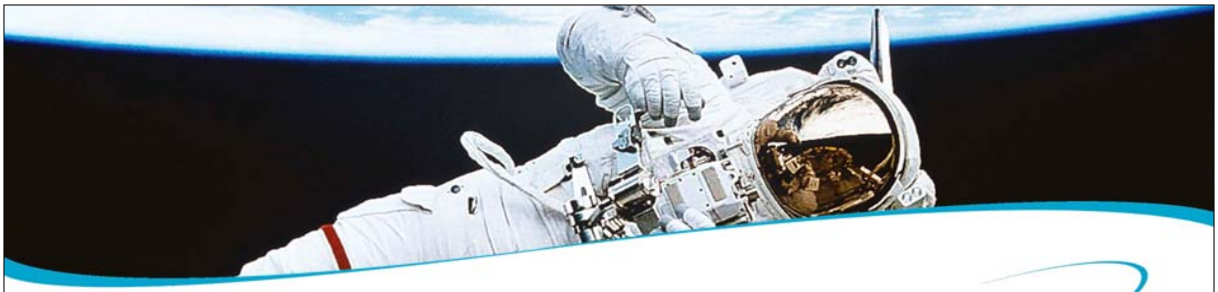
(Thales, France)

Abstract

The aim of the study is to assess the interest of using probabilistic methods and tools for the thermal design of a telecom satellite. This work has been done in the frame of system development for new satellites.
In the past the interest of such methods compared to deterministic approach leading to use of margin has been pointed locally in the system. It was concluded that these methods are useful to have a more clear and complete exploration of the design and system performances, and thus to identify easily sizing parameters among many inputs. Moreover by associating an occurrence probability to system temperatures related to the dispersion law of relevant input parameters, stochastic approach is expected to avoid a final risky or oversized design.
Here we assess the feasibility of such approach at system level on a telecom satellite by benchmarking probabilistic versus margin method for a S/C communication module. The tools used for this study is OPTIMUS (stochastic methods and computation workfow) and ETHERM (TAS thermal solver)
In this purpose the classical margin approach is compared to a deterministic uncertainty analysis (RMS of cumulative incertainties on relevant parameters of the thermal design) and to a probabilistic approach (consideration of probabilistic distribution for relevant input parameters).
Methods, tools, and results are presented and current conclusions and perspectives are given considering technical and industrial objectives.



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Assessment of Stochastic Approach for Thermal Design of a Telecom Spacecraft

by Nicolas DONADEY (AKKA technology)
and Jean-paul DUDON, P CONNIL and P HUGONNOT (TAS)

28th ESA Space Thermal Analysis Workshop
14-15 oct 2015

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SUMMARY

1- INTRODUCTION TO STOCHASTIC APPROACH FOR UNCERTAINTY ANALYSIS

2- OBJECTIVES OF THE STUDY

3- METHODOLOGY FOR TELECOM S/C

4- RESULTS

5- CONCLUSION & PERSPECTIVES

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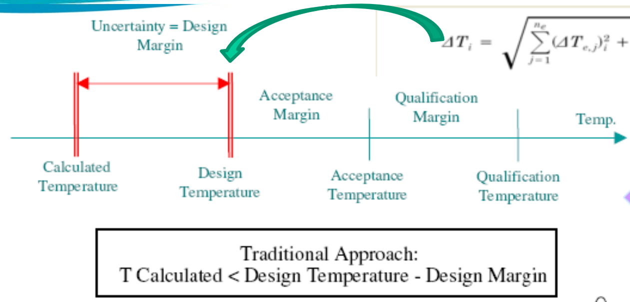
Thermal Uncertainty Analysis and Stochastic Approach

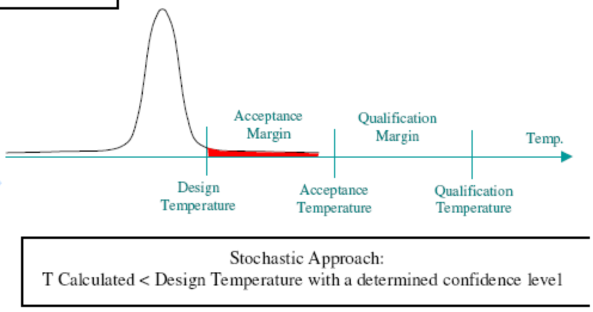
Page

$$\Delta T_i = \sqrt{\sum_{j=1}^{n_e}(\Delta T_{e,j})_i^2 + \sum_{k=1}^{n_p}(\Delta T_{p,k})_i^2 + \sum_{l=1}^{n_t}(\Delta T_{t,l})_i^2 + \sum_{r=1}^{n_m}(\Delta T_{m,r})_i^2 + (\Delta T_s)_i}$$



Design margins with traditional method

Design margins with stochastic method: design to fit with specific probability to remain within limits



Source : FSASTA ESA study, TAS-I, Blue : Feasibility of Stochastic Approach For Space Thermal Analysis, 2004

Corporate Communications

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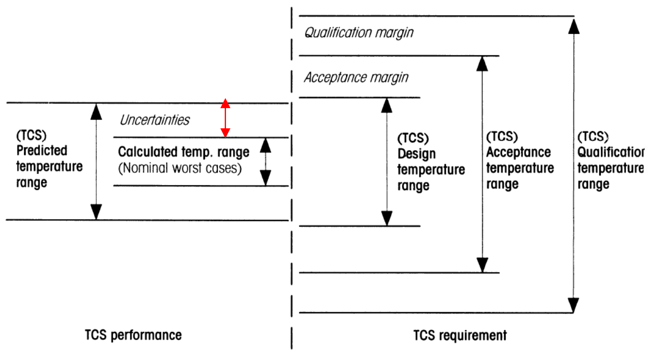
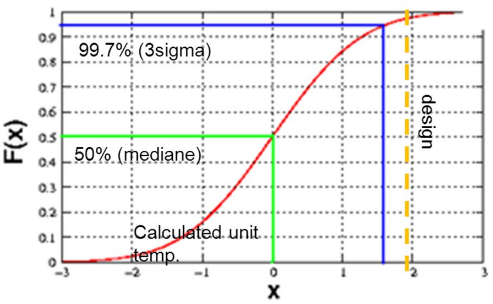
2- OBJECTIVES OF THE STUDY

For this study the questions to solve were :

Can we use the stochastic approach to assess the thermal design of a telecom spacecraft ?

Does it lead to a margin reduction and an increase of competitiveness compared to the margin approach ?





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3- METHODOLOGY

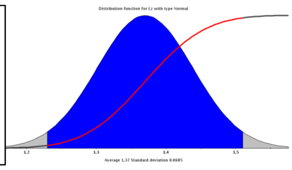
GENERAL APPROACH

THERMAL MODEL
OUTPUT PARAMETERS
THERMAL COMPUTATION CASE

→ TELCOM SAT
EPC LDLA RECEIVER DOCON BEACON TWT OMUX
WS EOL CONF1-3

THERMAL INPUTS AND VARIATION LAW

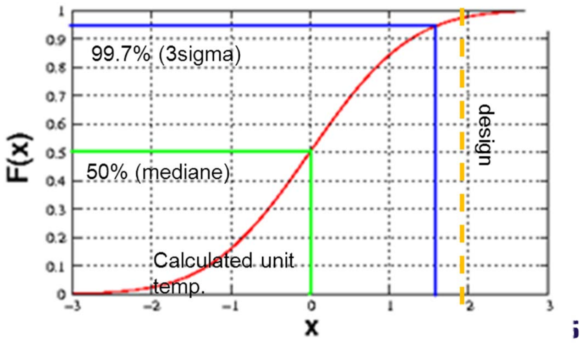
→ SOLAR CONSTANT
OPTICAL PROPERTIES
CONDUCTIVITY PROPERTIES
INTERNAL DISSIPATION
CAPACITANCE



WORKLOW OPTIMUS
INTERFACE OPTIMUS/ETHERM

RMS METHOD | MARGED APPROACH | STOCHASTIC METHOD

COMPARATIVE ANALYSIS



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3- METHODOLOGY

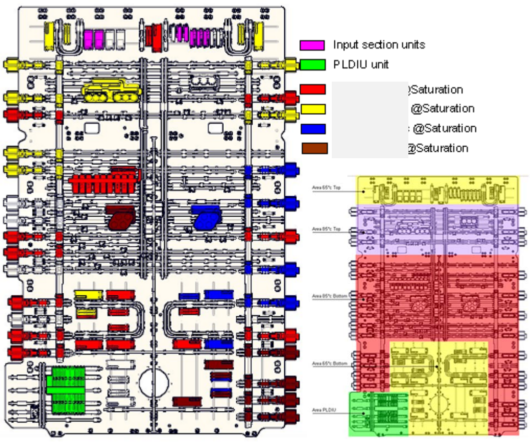
MODEL DESCRIPTION

For the study we selected the thermal model TELCOM SAT that was correlated with thermal vacuum test results.
Configuration case chosen : WS EOL CONF 1-3 (worst case with regard to our goal) .

In order to minimize the data volume, we focused on one of both CM N/S panels. But results shall be similar for the other one.

			Nomenclature	Trp
PAYLOAD South CM	Top 65°C	EPC	1EP403 (middle)	4766
		LDLA	1CL2-08 (+x)	4786
		RECEIVER	1RE3-05	4707
		DOCON	1DC1-03	4704
		BEACON	1BE2-01	4844
	Top 85°C	TWT	1TE403A (+x)	4694
		OMUX	1MS502(Northern)	4140
	Bottom 85°C	TWT	1TE309B (-x)	4574
		OMUX	1MS401 (Russian)	4145
	Bottom 65°C	EPC	1EP307 (-x)	4762
		LDLA	1CL2-09 (--x)	4796

TELCOM SAT CM SELECTED OUTPUT DATA



TELCOM CM Configuration 1-3

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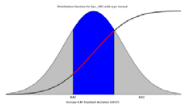
3- METHODOLOGY

COMPUTATION HYPOTHESIS



Dispersion law for inputs (range and form) taken from :

- ECSS-E-30-PART 1A : min/max range
- Doc 02,07,035/TN5 p226 (FSASTA study for ESA 2004) : law type
- Internal TAS applicable documents for thermal control (modeling error=2°C)

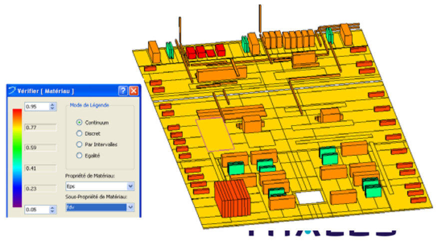
Variable inputs are grouped by type of coating, by material, by type of contact, …
The attached variation law is operated in the same way to all inputs of each group

- Ex: All the EPC surfaces have an emissivity equal to 0.85. If this value change from 0.85 to 0.86, each EPC will have an emissivity of 0,86
- Ex2 : All dissipations of the CM module are also varied in the same rate

			WS EOL 100% Drive		
			CONF 1-3		
			Tmax	Nomenclature	Trp
PAYLOAD South CM	Top 65°C	EPC	44.7	1EP403 (middle)	4766
		LDLA	44.3	1CL2-08 (+x)	4786
		RECEIVER	45.2	1RE3-05	4707
		DOCON	44.9	1DC1-03	4704
		BEACON	42.4	1BE2-01	4844
	Top 85°C	TWT	60.7	1TE403A (+x)	4694
		OMUX Northern (6ch)	54.4	1MS502(Northern)	4140
	Bottom 85°C	TWT	59.4	1TE309B (-x)	4574
		OMUX Russia (9ch)	56	1MS401 (Russian)	4145
	Bottom 65°C	EPC	32.5	1EP307 (-x)	4762
		LDLA	29.97	1CL2-09 (--x)	4796

TELCOM SAT CM NOMINAL TEMPERATURE FOR CONSIDERED UNITS

VIEW OF ETHERM RADIATIVE MODEL OF THE PANEL WITH UNITS



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3- METHODOLOGY

THERMAL INPUT PARAMETERS

					SIGMA (Loi gaussienne) Doc 02,07,035/TN5 p226		INCERTITUDE ECSS-E-30-PART 1A				
			Valeur nominal	Loi de variation	(%)	Sigma	%	Fixe	Borne min	Borne max	Affectation
CONDUCTIF	PANNEAU CM	Lx Ly	3,81	Normal	5	0,1905	10		**3,43**	**4,19**	**Fichier cas de calcul plateau**
		Lz	1,37	Normal	5	0,0685	10		**1,23**	**1,51**	
	CONDUCTANCE CONTACT	Heat-pipe/Stucture1	933,00	Normal	25	233,2500	25		**700**	**1166**	**Table gopl 41**
		Heat-pipe/Stucture2	2400,00	Normal	25	600,0000	25		**1800**	**3000**	
		Unit/Aluminium	1200,00	Normal	25	300,0000	25		**900**	**1500**	
		Heat-pipe/Xing	5000,00	Normal	25	1250,0000	25		**3750**	**6250**	**Table CONDHP 241**
		Unit/Heat-pipe	5000,00	Normal	25	1250,0000	25		**3750**	**6250**	
		coeff*	1,00	Normal	25	0,2500	25		**0,75**	**1,25**	
RADIATIF	INTERNE	Eps CAMP	0,50	Normal	5	0,0250		0,03	**0,47**	**0,53**	**Table alvéole interne 628**
		Eps E_D_R_O **(Eps__085)**	0,85	Normal	5	0,0425		0,03	**0,82**	**0,88**	
		Eps Z307_BEACON **(Eps_Z307)**	0,95	Normal	5	0,0475		0,03	**0,92**	**0,98**	
		Eps Z306_TWT **(Eps_Z306)**	0,90	Normal	5	0,0450		0,03	**0,87**	**0,93**	
		Eps NIDA	0,80	Normal	5	0,0400		0,03	**0,77**	**0,83**	
		Eps MLI **(Epsl_MLI)**	0,05	Normal	5	0,0025		0,02	**0,03**	**0,07**	
		Beq MLI (W/°C,mm²)	1,0000E-07	Normal	15	0,000000015	50		**5,00E-08**	**1,50E-07**	**Table appel 2624**
		Eps_eq MLI	0,0050	Normal	15	0,0008	50		**2,50E-03**	**7,50E-03**	
	EXTERNE	Alp OSR	0,255	Normal	5	0,0128		0,03	**0,23**	**0,29**	**Table alvéole externe 1062**
		Eps OSR	0,84	Normal	5	0,0420		0,03	**0,81**	**0,87**	
		Eps TWT	0,80	Normal	5	0,0400		0,03	**0,77**	**0,83**	
		Alp TWT	0,70	Normal	5	0,0350		0,03	**0,67**	**0,73**	
		Eps MLI	0,84	Normal	5	0,0420		0,03	**0,81**	**0,87**	
		Alp MLI	0,93	Normal	5	0,0465		0,03	**0,90**	**0,96**	
		Beq MLI (W/°C,mm²)	2,0000E-08	Normal	15	0,000000003	50		**1,000E-08**	**3,000E-08**	**Table appel 2624**
		Eps_eq MLI	0,0109	Normal	15	0,0016	50		**5,430E-03**	**1,629E-02**	
EXTERNE		Constante solaire	1418,00	Normal	10	141,8000		21,00	**1397**	**1439**	**Cas de calcul solaire**
CAPACITANCE	Cp	Equipement	1,00	Normal	5	0,0500	25		**0,75**	**1,25**	**Table 2174***
		Structure	1,00	Normal	5	0,0500	15		**0,85**	**1,15**	
PUISSANCE	CM	Table Puissance	1,00	Uniforme		0,0000	5		**0,95**	**1,05**	**Table 1893 ***
		Table Harness	1,00	Uniforme		0,0000	5		**0,95**	**1,05**	**Table 1888 ***
	TOTAL	**25**									

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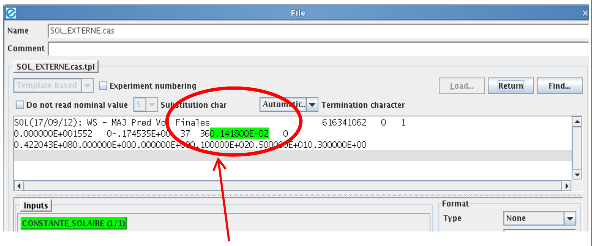
3- METHODOLOGY

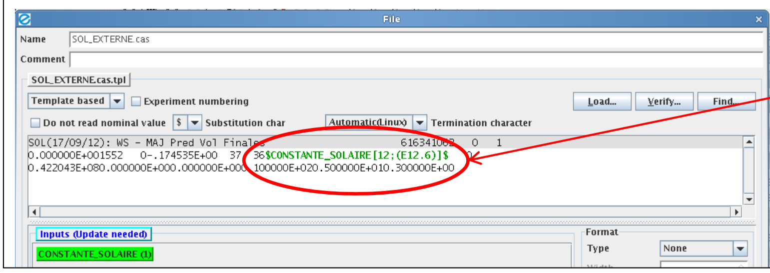
Brief presentation of OPTIMUS tool (by NOESIS)

For this study, OPTIMUS tool was used to manage and automatize all the computation process & to perform the stochastic analysis

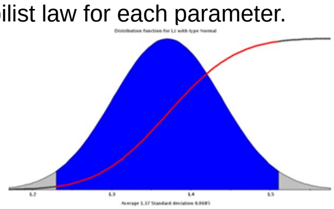
Typically OPTIMUS allows to :

- Attach probabilistic distributions to inputs
- Launch all required calculation cases (including parallel run capability) on any thermal tools (ETHERM here)
- Use many powerful stochastic & deterministic methods for model exploration, uncertainty & sensitivity and for optimisation (DOE, RSM, MCS, global optimisation,…)
- Post-process all results in an ergonomic and rapid way (table, graphics, …)





Via Optimus, the input parameters are changed as a variable.
The user can choose a different probabilist law for each parameter.



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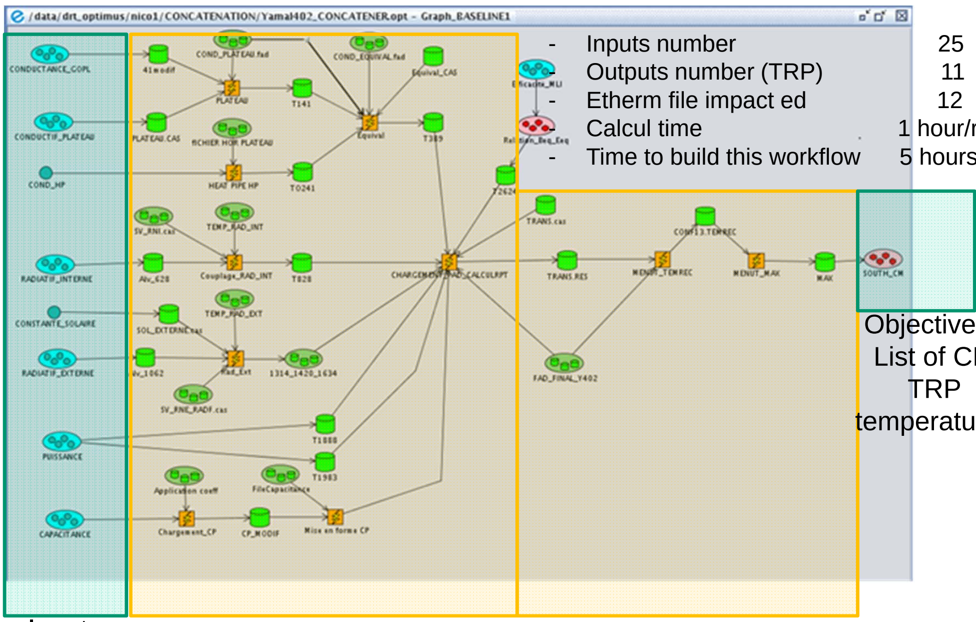
3- METHODOLOGY

OPTIMUS WORKFLOW with ETHERM thermal tool



- Inputs number 25
- Outputs number (TRP) 11
- Etherm file impact ed 12
- Calcul time 1 hour/run
- Time to build this workflow 5 hours

Objectives : List of CM TRP temperatures

Inputs parameters

ETHERM input files and exe (cond, rad, solver, …)

ETHERM output files and thermal post processing

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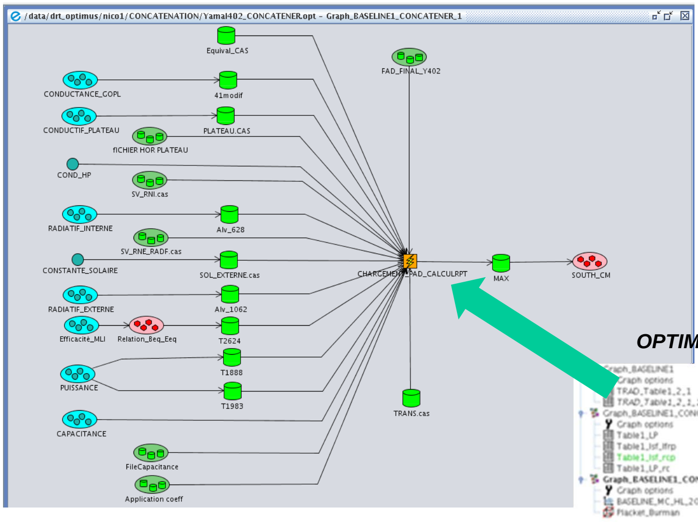
3- METHODOLOGY

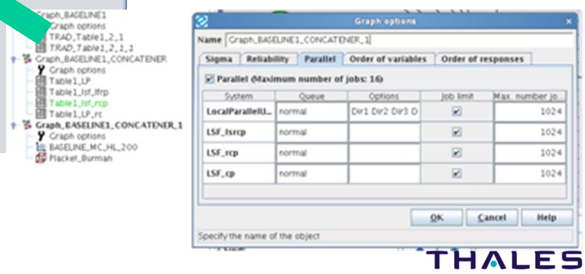
OPTIMUS WORKFLOW for parallel computations



In order to optimize the computation time a parallel workflow was built to run 16 cases at a time

In nominal condition, **1000 computations are performed in 3 days for the whole CM model**

OPTIMUS option box for parallel computation



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3- METHODOLOGY

TRADITIONAL METHOD VS STOCHASTIC METHOD

TRADITIONAL APPROACH
Root Mean Square (RMS)

- The traditional approach to determine uncertainty is a root mean square :
- We consider each parameter one by one as input
- For each run, all the parameters have their nominal value except the current one which have his worst value.
- For each unit the global temperature uncertainty is defined as :

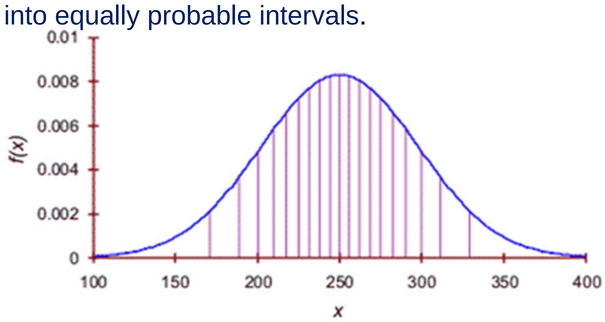
$$\Delta T^{RMS}{}_{unit} = \sum_{k}^{25} \sqrt{\Delta T_K{}^2}$$

with ΔT_k= T unit calc. with nominal value of parameter k - T unit calc.with worst value of k

STOCHASTIC APPROACH
MONTE CARLO WITH LATIN HYPERCUBE

MCS : N samples (N=1000) of K variables (K=25) are randomly produced and the thermal model is run N times with these samples.

Latin hypercube sampling (LHS) is a statistical method used to optimize efficiency of MCS and respect the initial distribution (gaussian, truncated or uniform). The range of each variable is divided into equally probable intervals.



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4- RESULTS

RMS uncertainty analysis results

11 units ➔

25 parameters

			Valeur nominal	Valeur	PAYLOAD South CM										
					Top 65°C					Top 85°C		Bottom 85°C		Bottom 65°C	
				Elément	EPC	LDLA	RECEIVER	DOCON	BEACON	TWT	OMUX Northern (6ch)	TWT	OMUX Russia (9ch)	EPC	LDLA
				Nomenclature	1EP403 (middle)	1CL2-08 (+x)	1RE3-05	1DC1-03	1BE2-01	1TE403A (+x)	1MS502(Northern)	1TE309B (-x)	1MS401 (Russian)	1EP307 (-x)	1CL2-09 (--x)
				Trp	**4766**	**4786**	**4707**	**4704**	**4844**	**4694**	**4140**	**4574**	**4145**	**4762**	**4796**
				Tnominal	44,7	44,26	45,33	44,91	42,51	60,72	54,43	59,46	56,01	32,8	30,01
CONDUCTIF	PANNEAU CM	Lx Ly	3,81	**3,43**	0,17	0,35	0,24	0,23	0,16	0,43	0,43	0,48	0,47	0,09	-0,10
		Lz	1,37	**1,23**	0,25	0,38	0,26	0,26	0,28	0,53	0,55	0,54	0,55	0,22	0,24
	CONDUCTANCE CONTACT	Heat-pipe/Stucture1	933,00	**700**	-0,02	0,00	-0,03	-0,02	-0,03	0,06	0,06	0,05	0,06	0,00	0,01
		Heat-pipe/Stucture2	2400,00	**1800**	0,08	0,03	0,06	0,08	0,05	0,01	0,01	0,01	0,00	0,06	0,03
		Unit/Aluminium	1200,00	**900**	0,19	0,28	0,38	0,33	0,20	0,00	0,00	0,00	0,00	0,17	0,15
		Heat-pipe/Xing	5000,00	**3750**	0,42	-0,21	0,08	0,25	-0,04	0,92	-0,47	0,39	-0,08	0,51	0,01
		Unit/Heat-pipe	5000,00	**3750**											
		coeff*	1,00	**0,75**											
RADIATIF	INTERNE	Eps CAMP	0,50	**0,53**	0,00	0,06	0,00	0,01	0,00	0,00	0,00	0,00	0,00	0,00	0,01
		Eps E_D_R_O **(Eps__085)**	0,85	**0,88**	-0,03	-0,01	-0,03	-0,03	-0,01	0,00	0,00	0,00	-0,01	-0,03	0,00
		Eps Z307_BEACON **(Eps_Z307)**	0,95	**0,98**	0,00	0,00	0,00	0,01	0,00	0,00	0,00	0,00	0,00	0,00	0,00
		Eps Z306_TWT **(Eps_Z306)**	0,90	**0,93**	0,00	0,00	0,00	0,00	0,00	0,00	0,00	-0,01	0,00	0,00	0,00
		Eps NIDA	0,80	**0,83**	0,02	0,04	0,01	0,02	0,02	-0,01	-0,01	0,00	0,00	0,00	0,01
		Eps MLI **(Epsl_MLI)**	0,05	**0,07**	0,06	0,06	0,05	0,07	0,05	-0,11	-0,12	-0,12	-0,13	0,06	0,06
		Beq MLI (W/°C,mm²)	1,0000E-07	**1,50E-07**	0,06	0,06	0,05	0,07	0,05	-0,09	-0,10	-0,09	-0,10	0,06	0,07
		Eps_eq MLI	0,0050	**7,50E-03**											
	EXTERNE	Alp OSR	0,255	**0,29**	2,54	2,52	2,54	2,54	2,62	2,62	2,69	2,61	2,69	2,57	2,73
		Eps OSR	0,84	**0,81**	2,05	2,04	2,04	2,04	2,11	2,24	2,30	2,21	2,30	1,83	1,98
		Eps TWT	0,80	**0,83**	0,03	0,03	0,03	0,03	0,03	0,21	0,15	0,21	0,15	0,02	0,04
		Alp TWT	0,70	**0,73**	0,01	0,01	0,01	0,01	0,01	0,07	0,05	0,07	0,05	0,00	0,02
		Eps MLI	0,84	**0,87**	-0,01	-0,01	-0,01	-0,01	-0,01	-0,02	-0,02	-0,02	-0,02	-0,01	0,00
		Alp MLI	0,93	**0,96**	0,01	0,01	0,01	0,01	0,01	0,01	0,02	0,01	0,01	0,01	0,01
		Beq MLI (W/°C,mm²)	2,0000E-08	**3,000E-08**	0,00	-0,01	0,00	0,00	0,01	0,02	0,02	0,01	0,01	-0,01	0,01
		Eps_eq MLI	0,0109	**1,629E-02**											
EXTERNE		Constante solaire	1418,00	**1439**	0,37	0,37	0,36	0,37	0,37	0,39	0,38	0,38	0,37	0,38	0,39
CAPACITANE	Cp	Equipement	1,00	**0,75**	0,01	0,00	0,00	0,01	0,01	0,00	0,02	0,03	0,01	0,01	0,02
		Structure	1,00	**0,85**	0,02	0,01	0,01	0,02	0,02	0,00	0,00	0,01	0,00	0,02	0,02
PUISSANCE	CM	Table Payload CM	1,00	**1,05**	2,43	2,39	2,45	2,44	2,36	3,03	2,82	2,97	2,91	1,86	1,85
		Table Harness	1,00	**1,05**	0,01	0,02	0,01	0,02	0,01	0,01	0,01	0,01	0,01	0,07	0,07
				RMS	**4,13**	**4,09**	**4,13**	**4,13**	**4,14**	**4,75**	**4,62**	**4,63**	**4,66**	**3,73**	**3,88**
		Prise en compte de l'erreur modèle (2°C)			2	2	2	2	2	2	2	2	2	2	2
			2	**RMS 2°C**	**4,58**	**4,56**	**4,59**	**4,58**	**4,60**	**5,16**	**5,04**	**5,04**	**5,07**	**4,23**	**4,37**
		RMS 2°C -RMS (pour étude stochastique)			**0,46**	**0,46**	**0,46**	**0,46**	**0,46**	**0,40**	**0,41**	**0,41**	**0,41**	**0,50**	**0,49**

Total RMS error for each unit ➔

A highly automated computation process that gives RMS uncertainty & confirms the list of influent parameters issued from RSM contribution (CM dissipations, α_{OSR} , ε_{OSR})

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4- RESULTS

Stochastic uncertainty analysis results Glossary

Cumulative distribution function (CDF)
The cumulative distribution function describes the probability for the unit temperature to have a value less than or equal to a limit (nominal, design, acceptance, …)

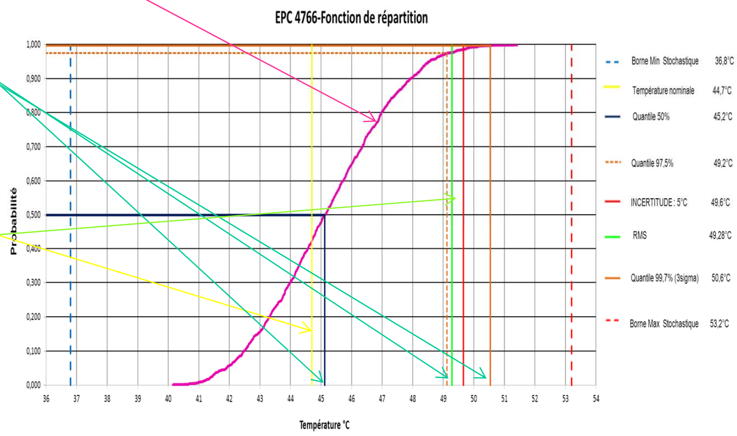
Quantiles (50% / 97.5% / 99.7%)
Quantile are points taken at regular intervals from the CDF.
99.7% quantile correspond to 3sigma design

Nominal temperature
Temperature calculated when all the parameter have their nominal value.

RMS Temperature
Temperature error obtained with RMS method considering the accumulation of effect of all the input parameters of the study (added to nominal temp)

Uncertainty margin 5°C : Tnominal +5°C

Boundary temperature (min and max)
The lowest and highest temperature obtained over the 1000 runs



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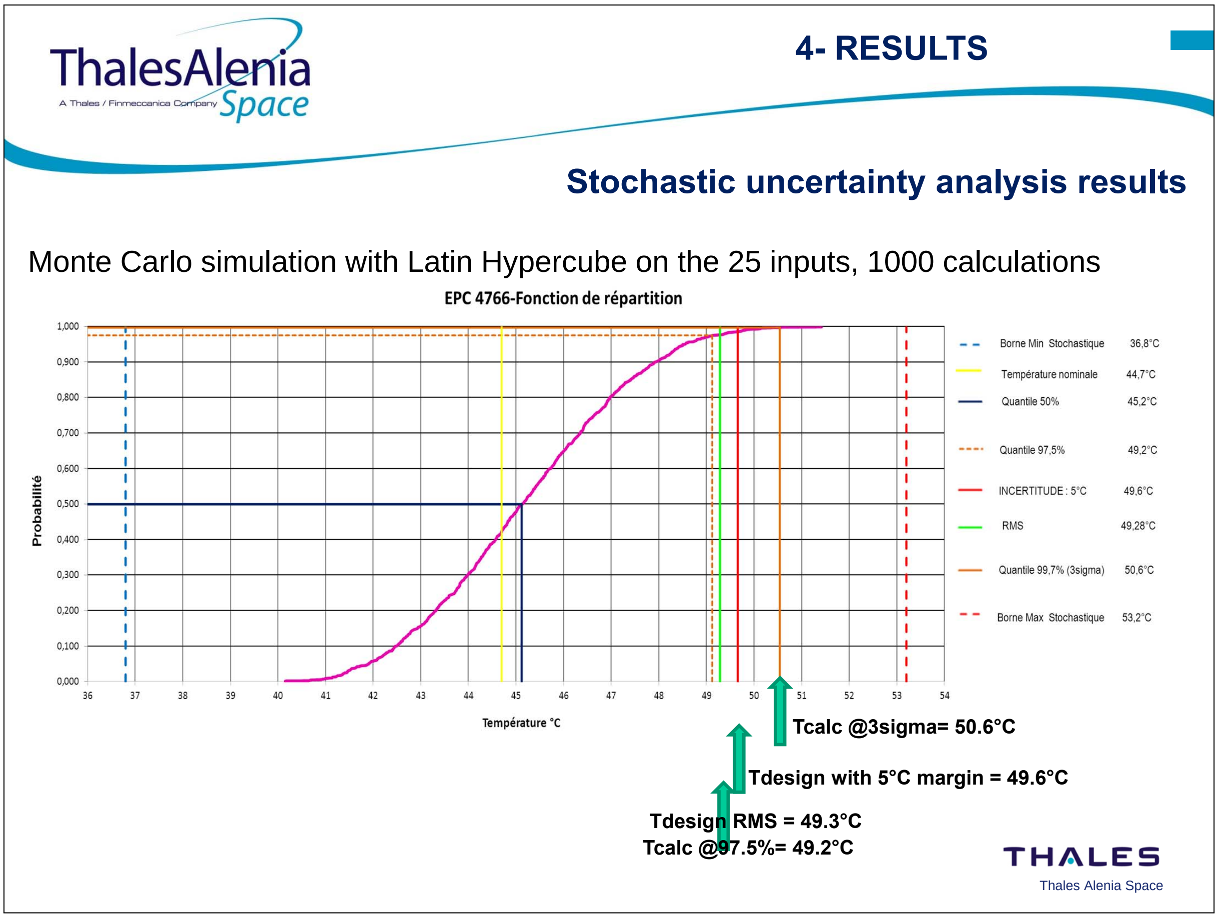
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4- RESULTS
Stochastic uncertainty analysis results
Monte Carlo simulation with Latin Hypercube on the 25 inputs, 1000 calculations
EPC 4766-Fonction de répartition
Probabilité
Température °C
Borne Min Stochastique 36,8°C
Température nominale 44,7°C
Quantile 50% 45,2°C
Quantile 97,5% 49,2°C
INCERTITUDE : 5°C 49,6°C
RMS 49,28°C
Quantile 99,7% (3sigma) 50,6°C
Borne Max Stochastique 53,2°C
Tcalc @3sigma= 50.6°C
Tdesign with 5°C margin = 49.6°C
Tdesign RMS = 49.3°C
Tcalc @97.5%= 49.2°C
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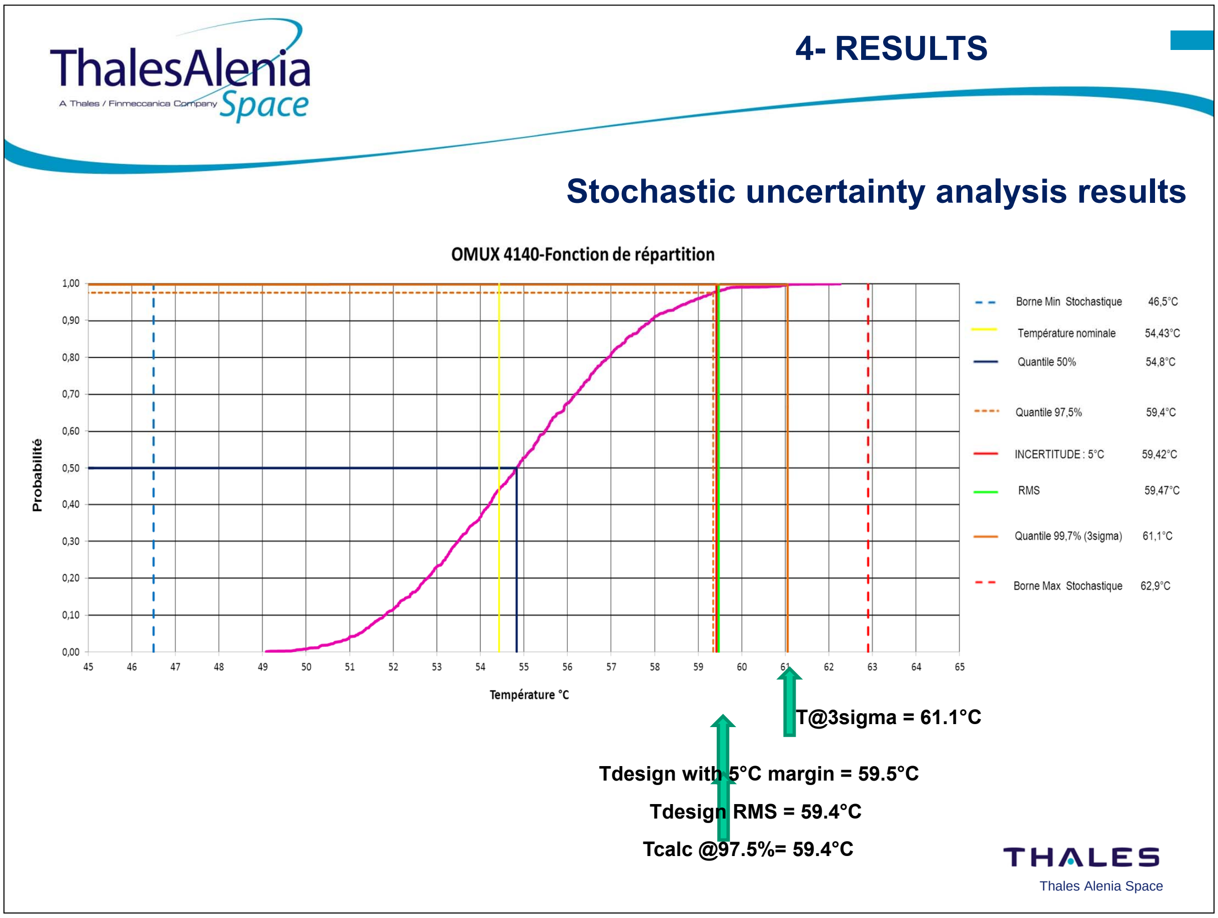
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4- RESULTS
Stochastic uncertainty analysis results
OMUX 4140-Fonction de répartition
Probabilité
Température °C
Borne Min Stochastique 46,5°C
Température nominale 54,43°C
Quantile 50% 54,8°C
Quantile 97,5% 59,4°C
INCERTITUDE : 5°C 59,42°C
RMS 59,47°C
Quantile 99,7% (3sigma) 61,1°C
Borne Max Stochastique 62,9°C
T@3sigma = 61.1°C
Tdesign with 5°C margin = 59.5°C
Tdesign RMS = 59.4°C
Tcalc @97.5%= 59.4°C
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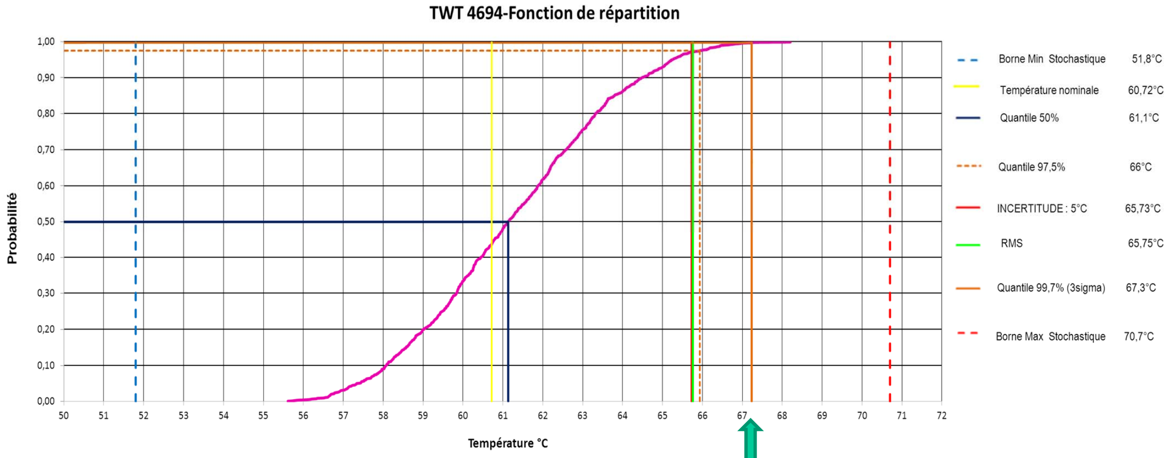
4- RESULTS

Stochastic uncertainty analysis results



T@3sigma = 67.3°C

Tdesign with 5°C margin = 65.8°C

Tdesign RMS = 65.7°C

Tcalc @97.5%= 66°C

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4- RESULTS

SUMMARY OF RESULTS

						INCERTITUDE CALCUL MODELE YAMAL 402 CONFIGURATION: WS EOL 100% Drive CONF 1-3								
						TRADITIONELLE			STOCHASTIQUE (T en °C)					
			Nomenclature	Trp	Tnominal °C	Incertitude: + 5°C	RMS		50% (médian)		97,5% (		99% (3sigma)	
							T °C	DT	T Calculé	Ecart (Tc-Tston)	T Calculé	Ecart (Tc-Tn)	T Calculé	Ecart (Tc-Tn)
South CM	Top 65°C	EPC	1EP403 (middle)	4766	44,7	49,7	49,3	4,6	45,2	0,5	49,2	4,5	50,6	5,9
		LDLA	1CL2-08 (+x)	4786	44,3	49,3	48,9	4,6	44,8	0,5	48,6	4,3	50,2	5,9
		RECEIVER	1RE3-05	4707	45,3	50,3	49,9	4,6	45,8	0,5	49,9	4,6	51,2	5,9
		DOCON	1DC1-03	4704	44,9	49,9	49,5	4,6	45,4	0,5	49,5	4,6	50,8	5,9
		BEACON	1BE2-01	4844	42,5	47,5	47,1	4,6	43,0	0,5	46,9	4,4	48,5	6,0
PAYLOAD	Top 85°C	TWT	1TE403A (+x)	4694	60,7	65,7	65,9	5,2	61,1	0,4	66,0	5,3	67,3	6,6
		OMUX Northern	1MS502(Northern)	4140	54,4	59,4	59,4	5,0	54,8	0,4	59,4	5,0	61,1	6,7
	Bottom 85°C	TWT	1TE309B (-x)	4574	59,5	64,5	64,5	5,0	59,9	0,4	64,5	5,0	66,0	6,5
		OMUX Russia	1MS401 (Russian)	4145	56,0	61,0	61,1	5,1	56,4	0,4	61,0	5,0	62,6	6,6
	Bottom 65°C	EPC	1EP307 (-x)	4762	32,9	37,9	37,1	4,2	33,4	0,5	37,0	4,1	38,1	5,2
		LDLA	1CL2-09 (--x)	4796	30,0	35,0	34,3	4,4	30,5	0,5	34,2	4,2	35,6	5,6

The first target of the study is reached : probability was associated to calculated unit temperatures within a telecom system by taking into account uncertainties on inputs. It points out that :

DT RMS ≈ DT stochastique @97.5% ≈ 5°C = design margin <≈ DT@3sigma

➔ In this case the stochastic approach does not allow to reduce the usual margin of 5°C.

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CONCLUSIONS

Globally this study pointed out the following major conclusions :

- Feasibility of intensive sensitivity analysis of a telecom thermal model at low computation cost with OPTIMUS (not presented)
- Feasibility to associate reliable probability distributions to unit temperatures using the same workflow than for sensitivity (1000 runs thanks to parallel mode)
- This approach did not allow to reduce the usual margin of 5°C for the design,
- However it pointed out that this margin currently in use for design is
    - in agreement with RMS « exhaustive » computation
    - Is overpassed in less than 2 % of cases (by less than 2°C)

  ➔ With the current margin the thermal design is conservative, but not clearly oversized !

- OPTIMUS process was optimized :
  - Better interface OPTIMUS/Etherm
  - Possibility to execute lots of runs in parallel (more than 1000 runs at all).

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ON GOING ACTIONS & PERSPECTIVES

Complete the first probabilist approach on CM by taking into account the uncertainty on spatial distribution for dissipations and for P/L failure cases (TBC)

Improve and optimize OSR area (on going)
- Optimisation methods and automated workflow capability
- Sensible saving expected on analysis duration

Telecom S/C model correlation (on going)
- Model exploration, Optimisation methods, automated workflow capability
- **Particular interest targeted** : performing correlation and flight prediction in a same coupled computation process (weeks of saving expected)

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