PCM-HSD design, Assembly and Flight Testing

Final Presentation

Agenda

1. Introduction by Walopt
2. Presentation of the main results of the Project
3. Conclusion
4. AOB

Executive Summary

The objective of the Activity was to define and build a Heat capacitor to support the thermal control system of a Hypersonic Glider, in the frame of the HEXAFLY-INT Project.

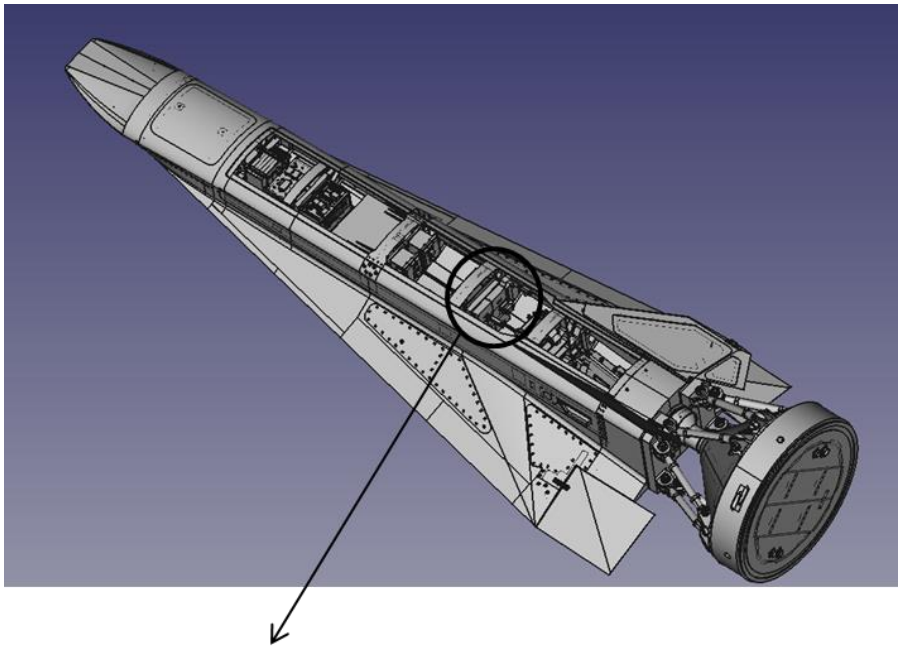
The technical specifications were supplied by ONERA and DLR-Moraba.

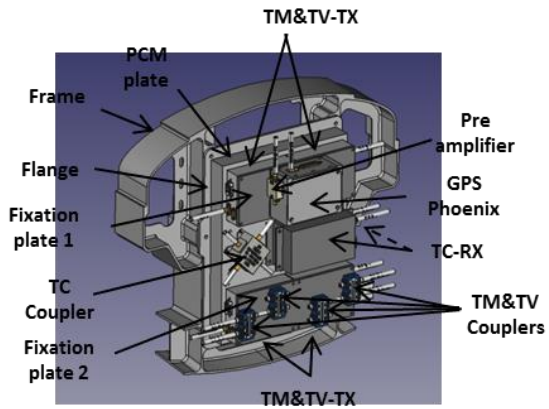
The foreseen flight has been postponed due to issues within the HEXAFLY-INT Project (Ukraine invasion). Therefore, this final presentation will not include post-flight data.

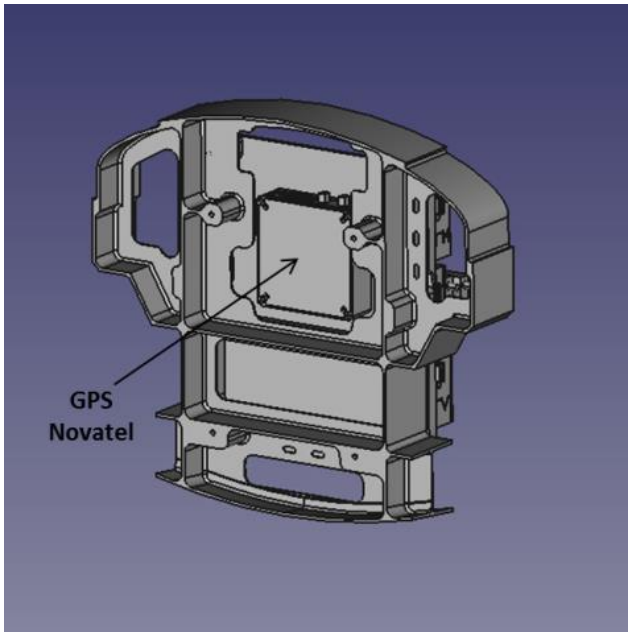
A full qualification program has been followed, including mechanical vibrations, tightness and vacuum thermal tests.

The main difficulties were in the implementation of multiple electronic units on a single heat capacitor. The mechanical function of supporting all these components has been added to the thermal function of the heat capacitor.

Specifications





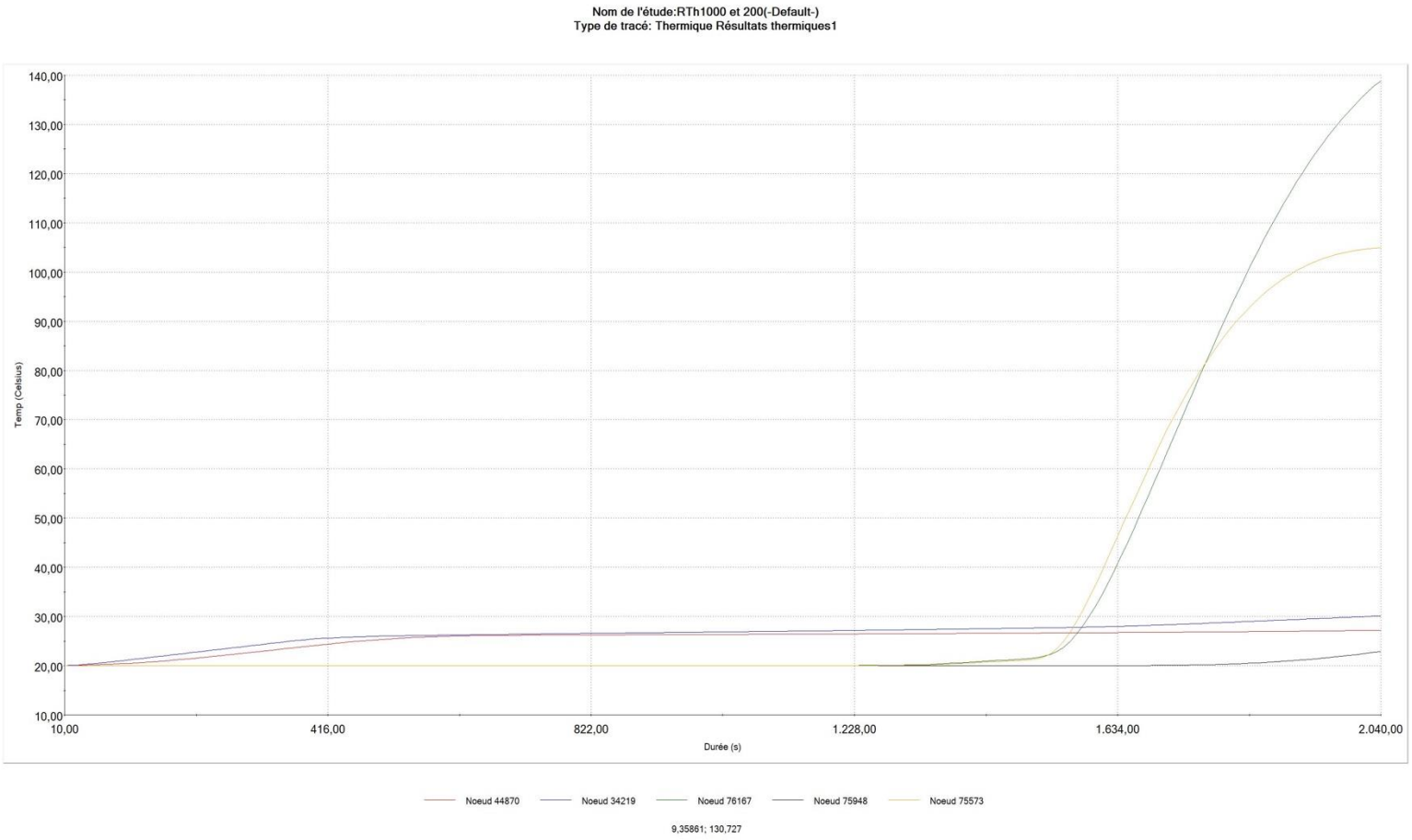


Specifications

Electronic Units	Mass (kg)	Dissipation (W)
TC-RX	0.2	2*2
TM&TV-TX	0.270	4*18
TM&TV Couplers	0.05	4*0.05
TC Coupler	0.068	0
GPS Novatel	0.330	1.3
GPS Phoenix	0.536	3
TOTAL		80.5

Specifications

Thermal interfaces with the 6 fixation points on the frame



Specifications

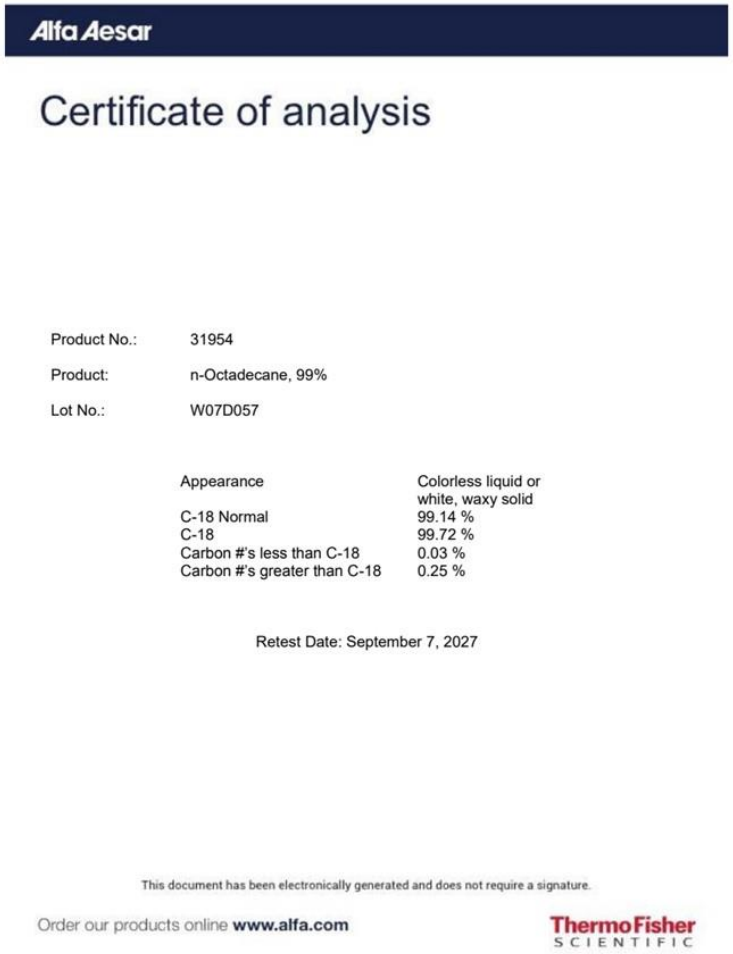
Mechanical loads

Ultimate Equivalent Static Load		
X	Y	Z
±30.8 g	± 9.98 g	± 9.36 g

X = 30,80 g corresponds to the axial load applied on the bolts fixing the e-units on the PCM-HSD)
Y = 9.98 g
Z = 9.36 g is towards the top/down sides of the glider

Design

PCM



Alfa Aesar

Certificate of analysis

Product No.: 31954

Product: n-Octadecane, 99%

Lot No.: W07D057

Appearance	Colorless liquid or white, waxy solid
C-18 Normal	99.14 %
C-18	99.72 %
Carbon #'s less than C-18	0.03 %
Carbon #'s greater than C-18	0.25 %

Retest Date: September 7, 2027

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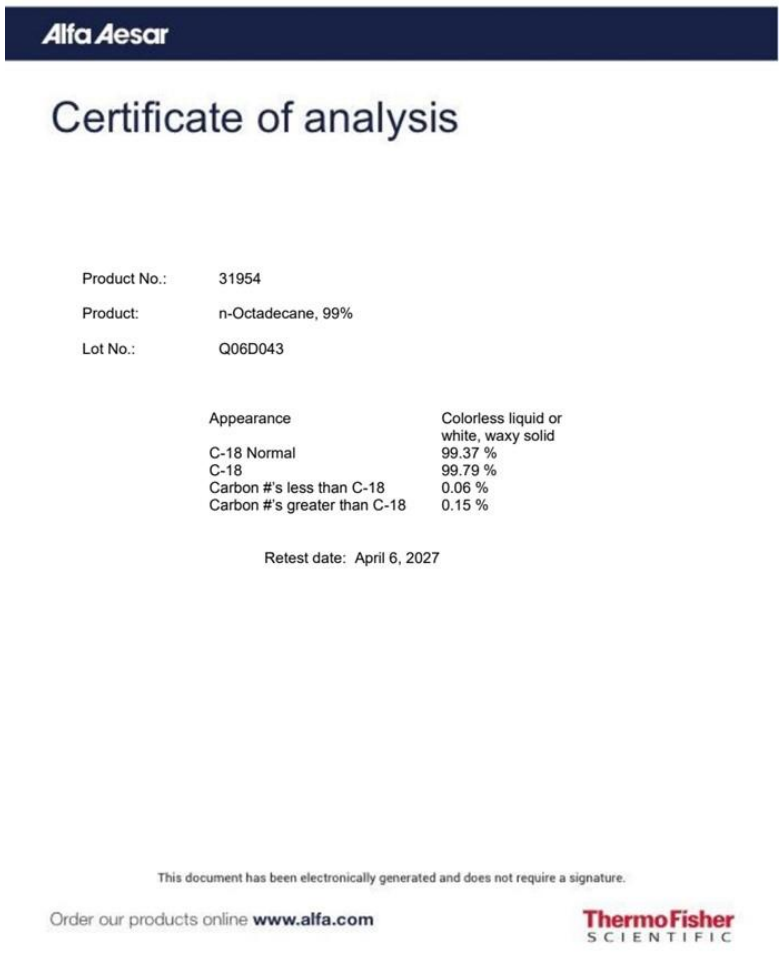

Alfa Aesar

Certificate of analysis

Product No.: 31954

Product: n-Octadecane, 99%

Lot No.: Q06D043

Appearance	Colorless liquid or white, waxy solid
C-18 Normal	99.37 %
C-18	99.79 %
Carbon #'s less than C-18	0.06 %
Carbon #'s greater than C-18	0.15 %

Retest date: April 6, 2027

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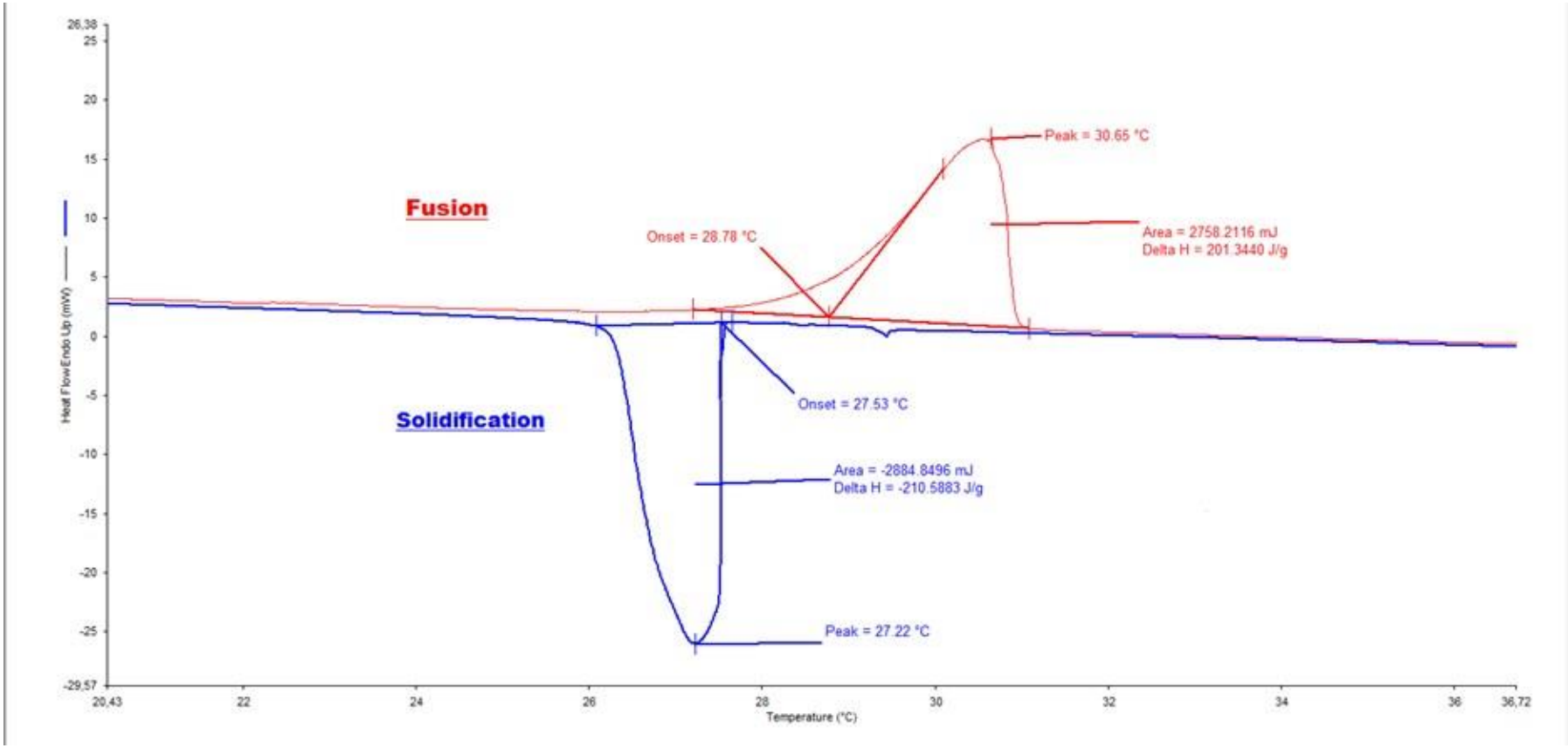
Design

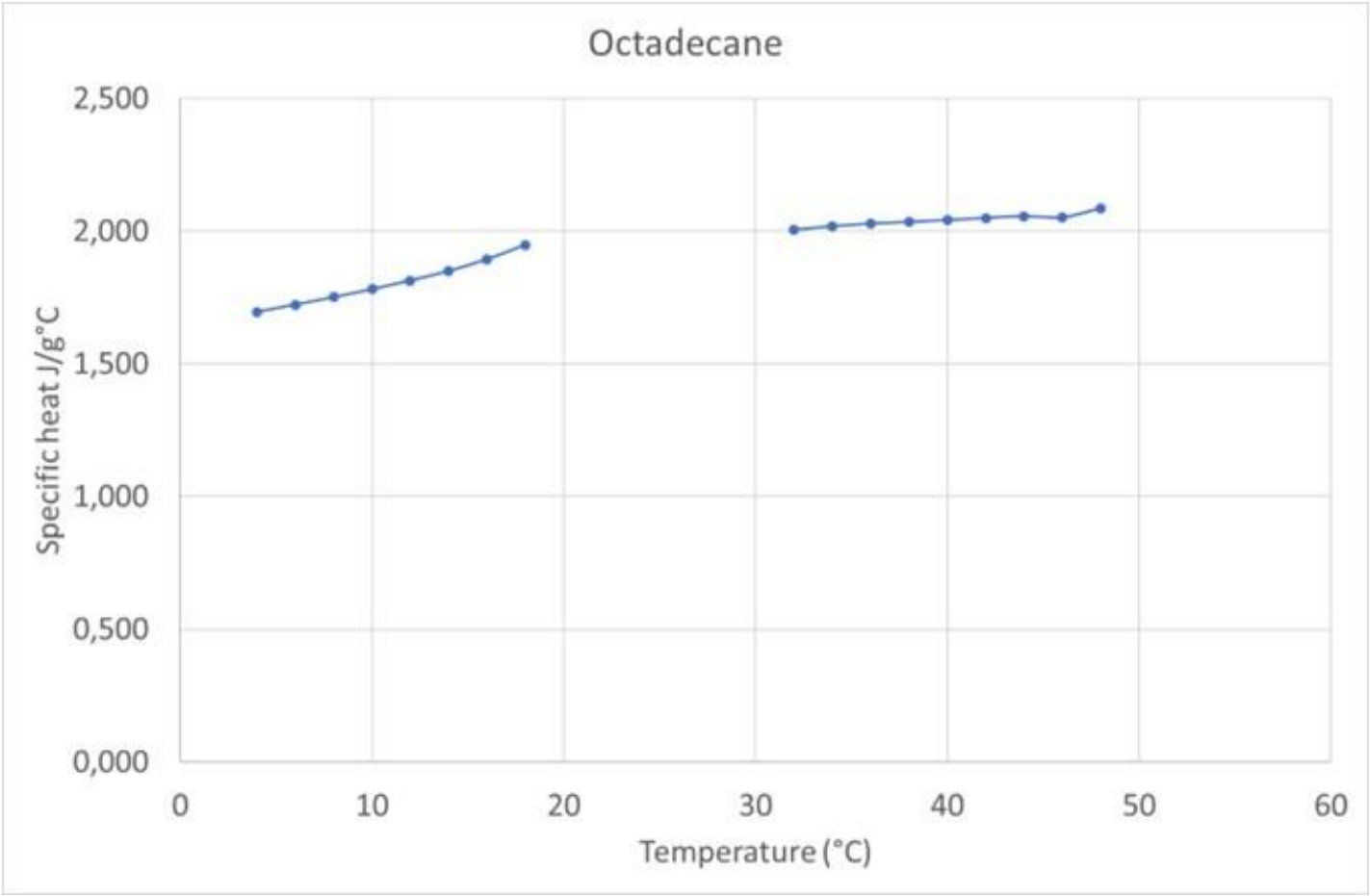
PCM



The average latent heat for melting and solidification are respectively 205 J/g and 218 J/g, which is in the expected range.
Specific heats in solid and liquid states were also measured.

Design

PCM



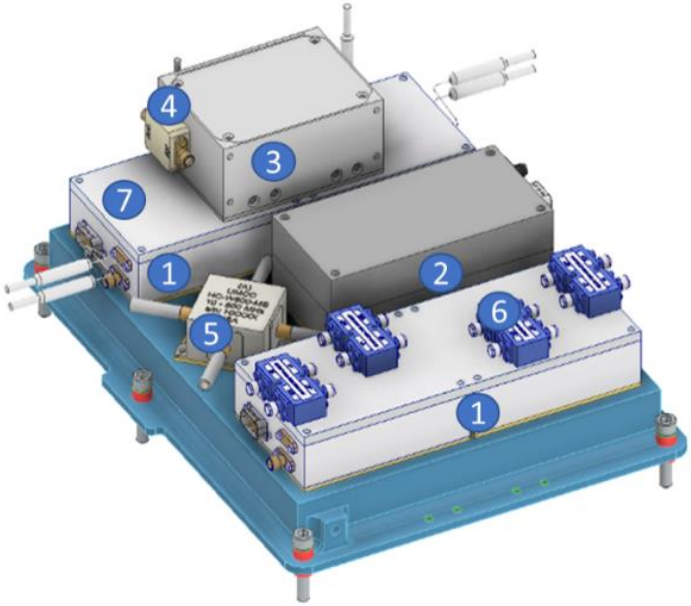
The specific heats are also in the expected range

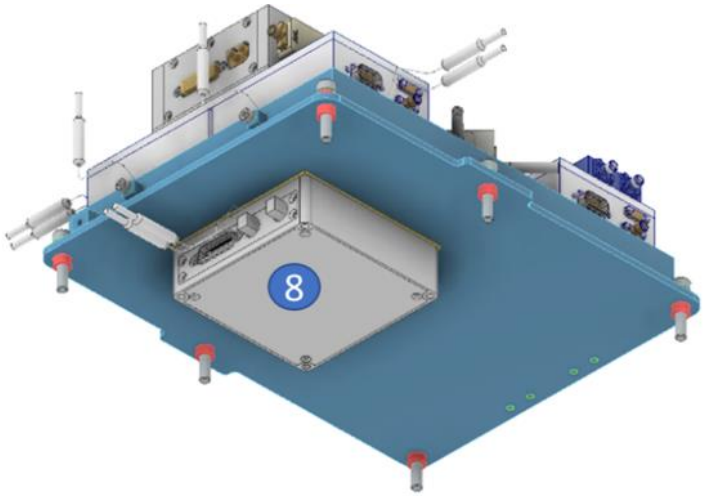
Design

First issue: the implementation of all the electronic components on a single Heat Capacitor Device

- Use of two supporting plates instead of 1
- Build up of some electronic units
- Non homogeneity of the heat flow into the heat capacitor
- Reinforcement of fixation on the supporting plate

Design





Design

Pressure resistance of a large container with wall reduced thickness

Welding performance

=> choice of a specific flange profile

- The max stresses are at the junction between the bottom plate and the lateral wall
- Addition of a 5 mm fillet at the most stressed region.
- The simulation gives, in this case, a larger safety margin: max Von Mises Stress = 59 MPa (VM/Sy=0,51 – 0,47)

Design

- The pre-load applied on the bolts fixing the electronic units has been defined and led to the design of the supporting plates.

- The fixation of the whole assembly PCM-HSD with the e-units will be done by a bolted connection to the Ti frame. The total mass of the PCM-HSD and the e-units mounted on the frame, is 5.263 Kg.

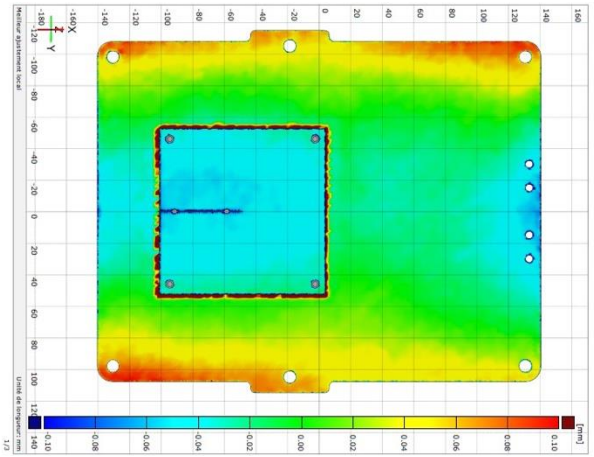
  The nominal value is the design target, and the min and max values account for preload uncertainty and relaxation.

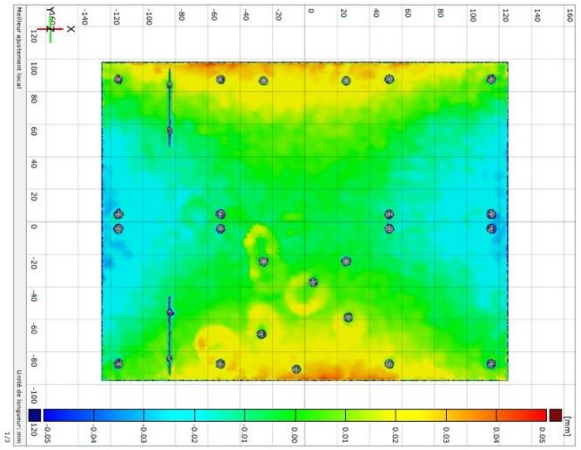
	Nominal	Minimum	Maximum
Preload Force:	6080.38 N	3952.3 N	7600.5 N
% of Yield Strength:	67.0%	43.6%	83.8%

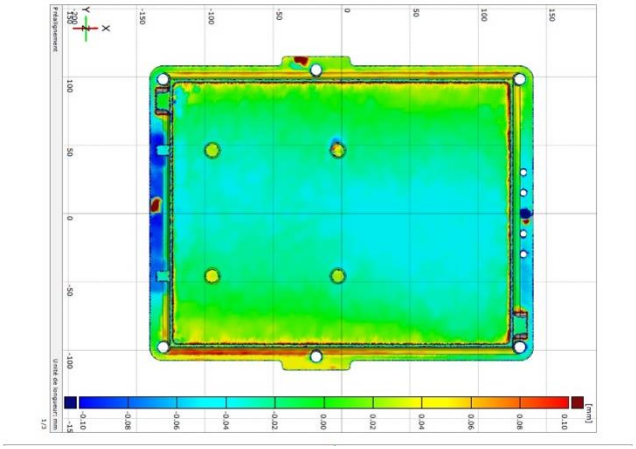
Manufacturing

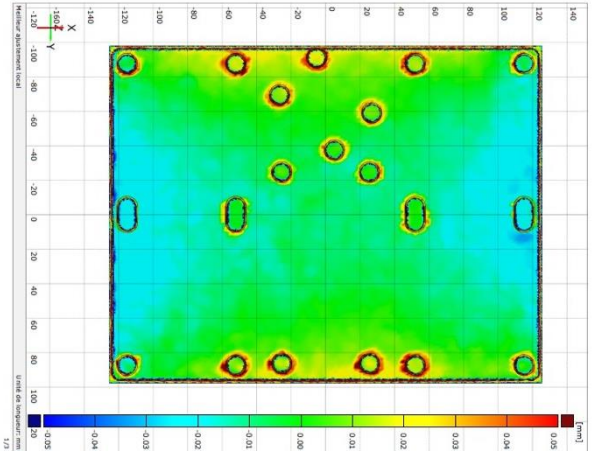
- Choice of the Al as best compromise, aluminum 5083, hardness assessment
- Choice of the PCM => n-octadecane
- AM not considered as too new at the time of design
- Complex machining =>multiple tests in the shop

Manufacturing



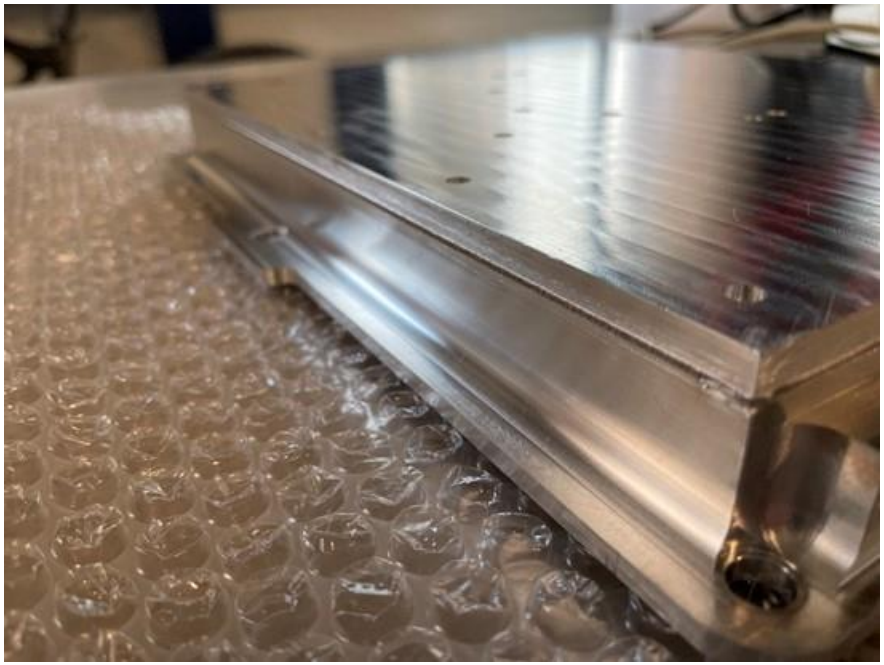






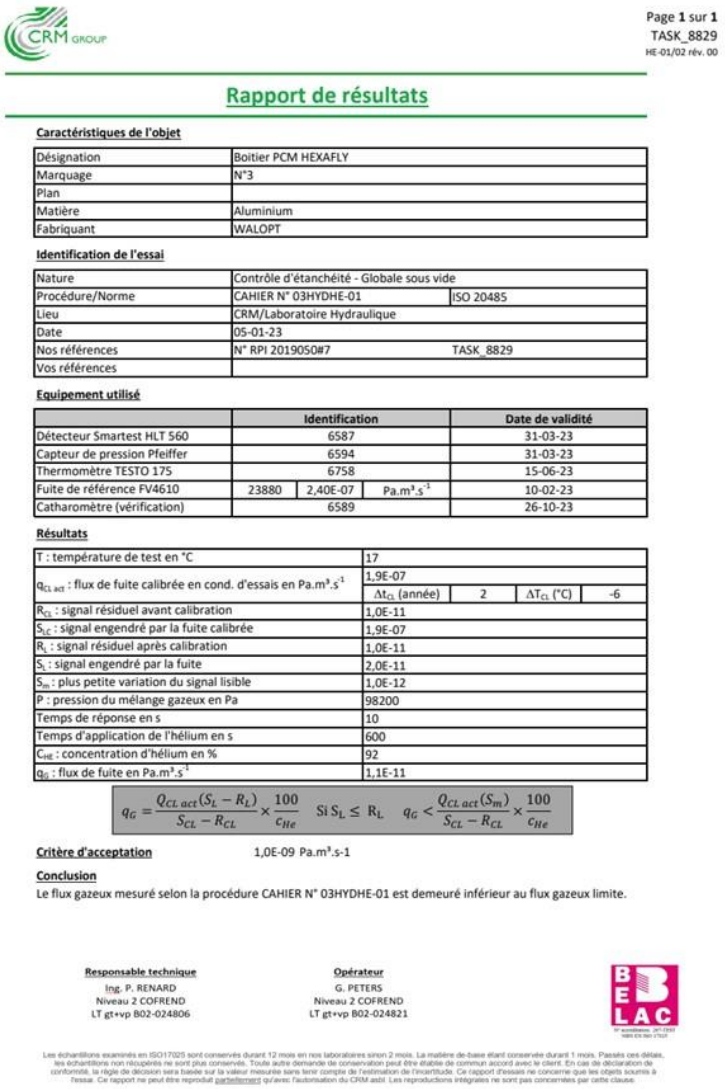
Size control meets the expectations

Manufacturing



Manufacturing

Samples are tight



CRM GROUP

Rapport de résultats

Caractéristiques de l'objet

Désignation	Boitier PCM HEXAFLY
Marquage	N°3
Plan	
Matière	Aluminium
Fabriquant	WALOPT

Identification de l'essai

Nature	Contrôle d'étanchéité - Globale sous vide	
Procédure/Norme	CAHIER N° 03HYDHE-01	ISO 20485
Lieu	CRM/Laboratoire Hydraulique	
Date	05-01-23	
Nos références	N° RPI 2019050#7	TASK_8829
Vos références		

Equipement utilisé

	Identification			Date de validité
Détecteur Smartest HLT 560	6587			31-03-23
Capteur de pression Pfeiffer	6594			31-03-23
Thermomètre TESTO 175	6758			15-06-23
Fuite de référence FV4610	23880	2,40E-07	$Pa.m^3.s^{-1}$	10-02-23
Catharomètre (vérification)	6589			26-10-23

Résultats

T : température de test en °C	17			
$q_{CL\ act}$: flux de fuite calibrée en cond. d'essais en $Pa.m^3.s^{-1}$	1,9E-07			
	Δt_{CL} (année)	2	ΔT_{CL} (°C)	-6
R_{CL} : signal résiduel avant calibration	1,0E-11			
S_{LC} : signal engendré par la fuite calibrée	1,9E-07			
R_L : signal résiduel après calibration	1,0E-11			
S_L : signal engendré par la fuite	2,0E-11			
S_m : plus petite variation du signal lisible	1,0E-12			
P : pression du mélange gazeux en Pa	98200			
Temps de réponse en s	10			
Temps d'application de l'hélium en s	600			
C_{He} : concentration d'hélium en %	92			
q_G : flux de fuite en $Pa.m^3.s^{-1}$	1,1E-11			

$$q_G = \frac{Q_{CL\ act}(S_L - R_L)}{S_{CL} - R_{CL}} \times \frac{100}{c_{He}} \quad \text{Si } S_L \leq R_L \quad q_G < \frac{Q_{CL\ act}(S_m)}{S_{CL} - R_{CL}} \times \frac{100}{c_{He}}$$

Critère d'acceptation 1,0E-09 $Pa.m^3.s\text{-}1$

Conclusion

Le flux gazeux mesuré selon la procédure CAHIER N° 03HYDHE-01 est demeuré inférieur au flux gazeux limite.

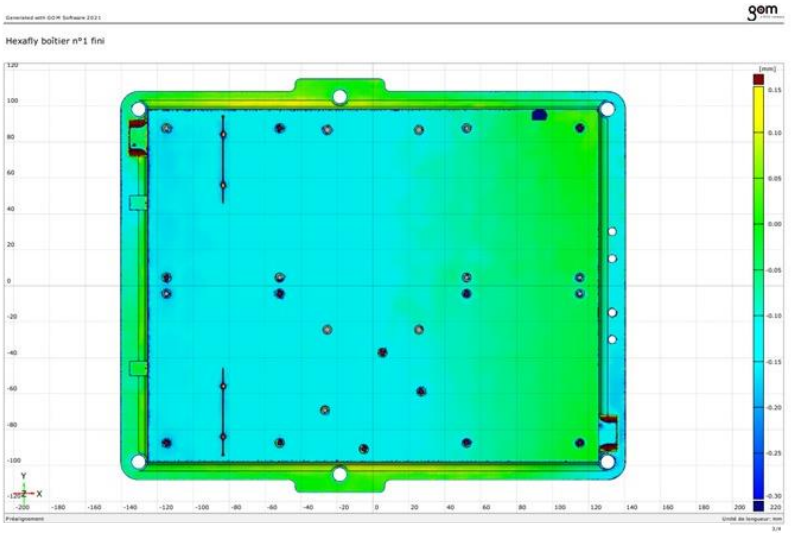
Responsable technique
Ing. P. RENARD
Niveau 2 COFREND
LT gt+vp B02-024806

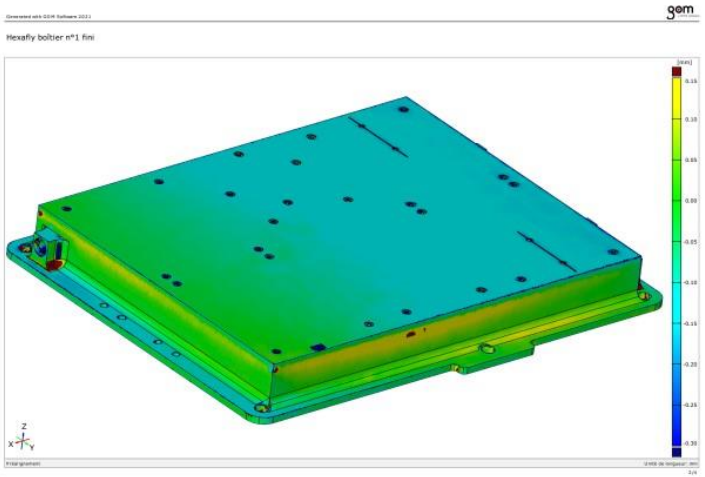
Opérateur
G. PETERS
Niveau 2 COFREND
LT gt+vp B02-024821

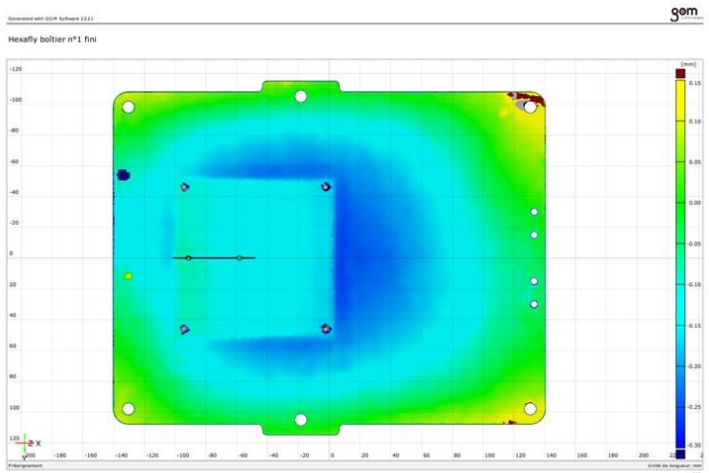
BELAC

Les échantillons examinés en ISO17025 sont conservés durant 12 mois en nos laboratoires sinon 2 mois. La matière de-base étant conservée durant 1 mois. Passés ces délais, les échantillons non récupérés ne sont plus conservés. Toute autre demande de conservation peut être établie de commun accord avec le client. En cas de déclaration de conformité, la règle de décision sera basée sur la valeur mesurée sans tenir compte de l'estimation de l'incertitude. Ce rapport d'essais ne concerne que les objets soumis à l'essai. Ce rapport ne peut être reproduit partiellement qu'avec l'autorisation du CRM asbl. Les reproductions intégrales ne sont pas concernées par cette clause.

Manufacturing







Samples after rectification

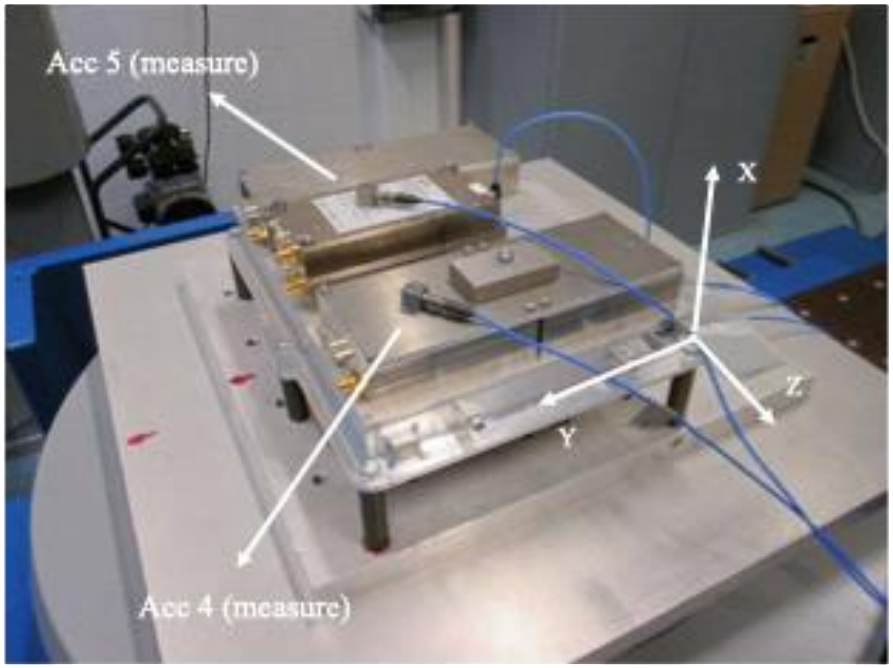
Manufacturing

Control of the thickness of the faces after rectification

Tests

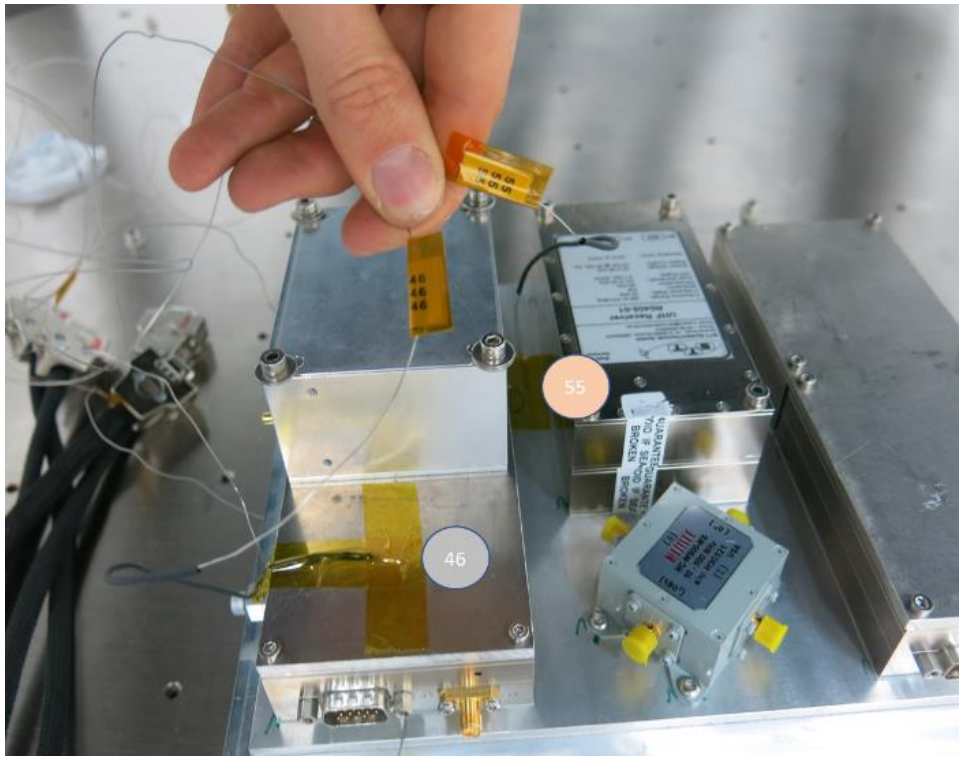
- Vibration tests

The first eigen frequency appearing along the X axis is 535 Hz, to be compared with a higher simulated value of 999 Hz. This can be explained by the low stiffness of the supporting set-up. No damage was observed after the random tests and the thermal tests realized after the vibration are as foreseen.



Tests

- Thermal vacuum test (DLR Moraba)



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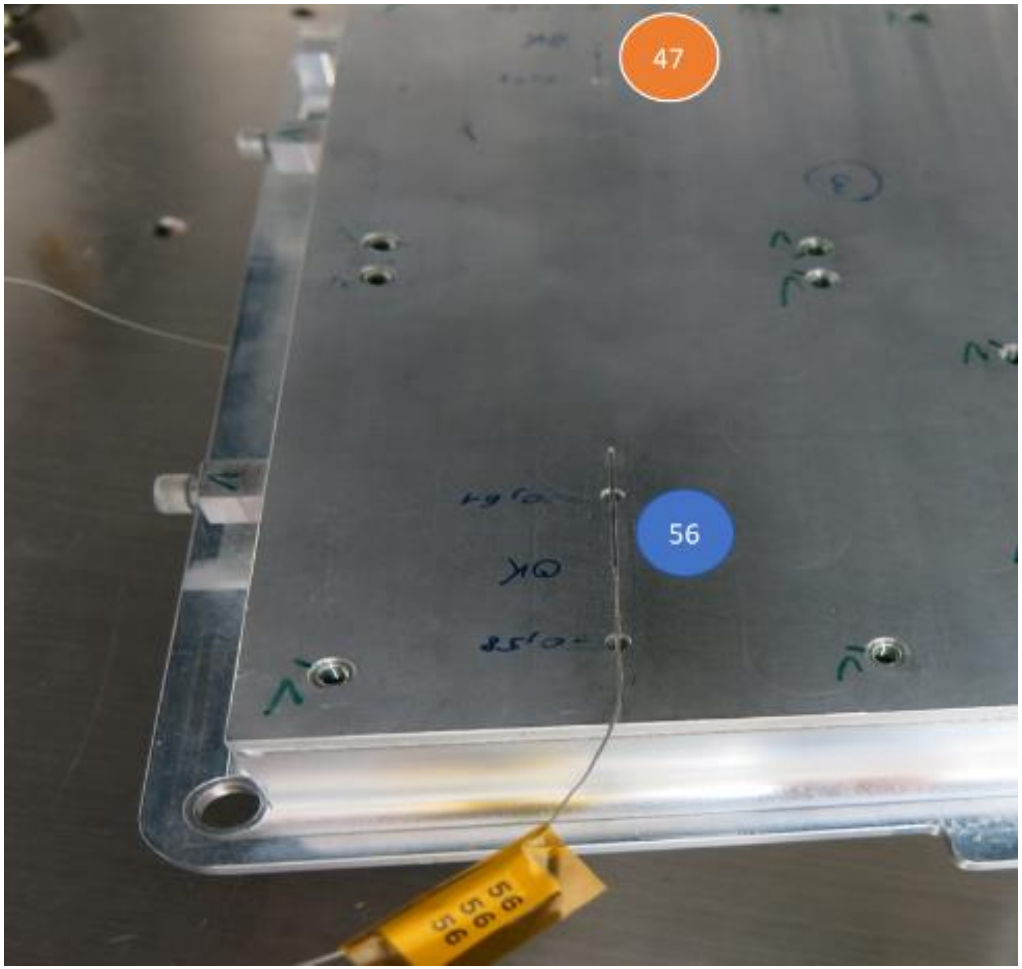

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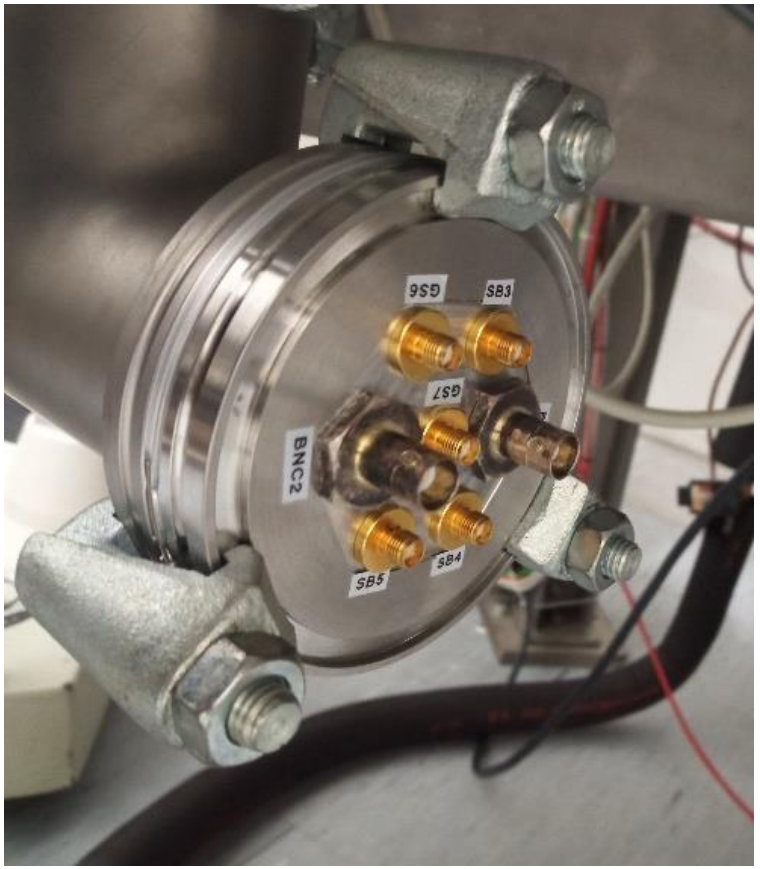

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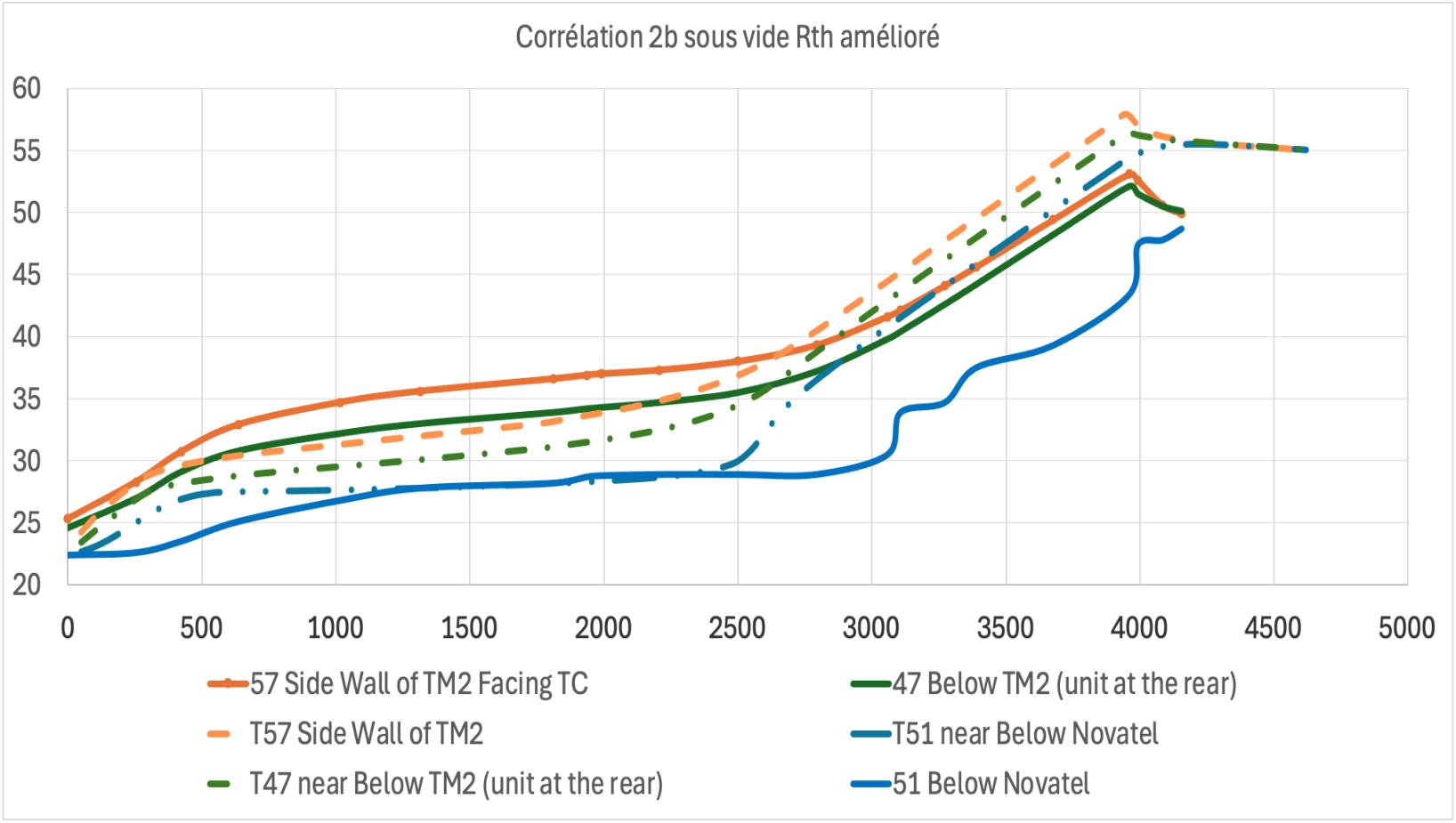

Tests

The simulation overestimates the maximum temperature; it comes from the margins used in the computations and of the PCM latent heat which is a bit higher.

The difference is about 6 °C for the hottest point and about 4 °C near the TM2 (below).

The measurement under the Novatel is somewhat erratic and is not considered.

The thermal resistance between TM's and PCM-HSD has been adapted to 0.056 K/W, which is very good.

Conclusions

- Objectives partially met:
  - Design and pre-manufacturing of an effective heat capacitor
  - The modelization is conservative. Some margins are still present before the flight.
  - The results underline the good sizing and dimensioning of the PCM-HSD.
- Flight data unavailable
  - Further work to be organized
- Closure of the Contract