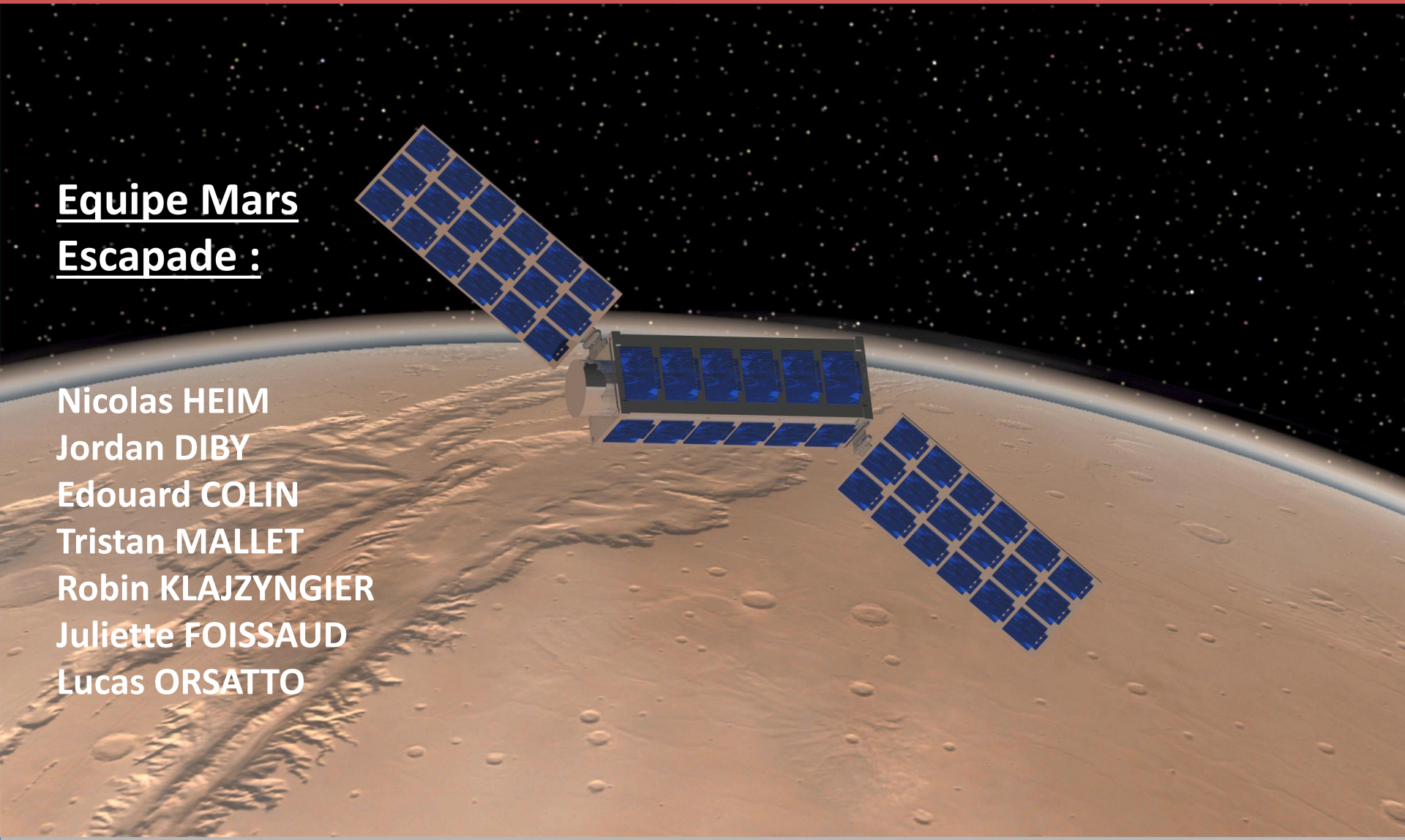
Conférence

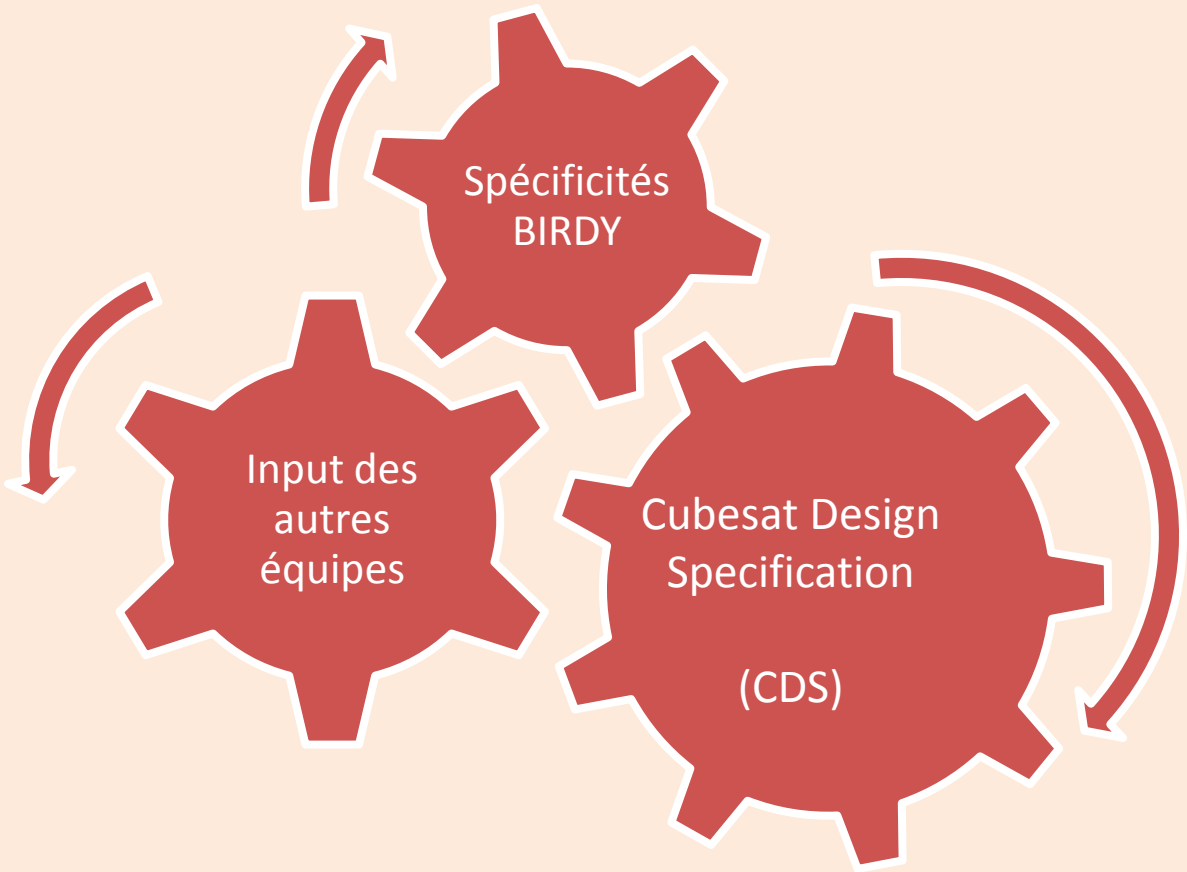


Equipe Mars Escapade :

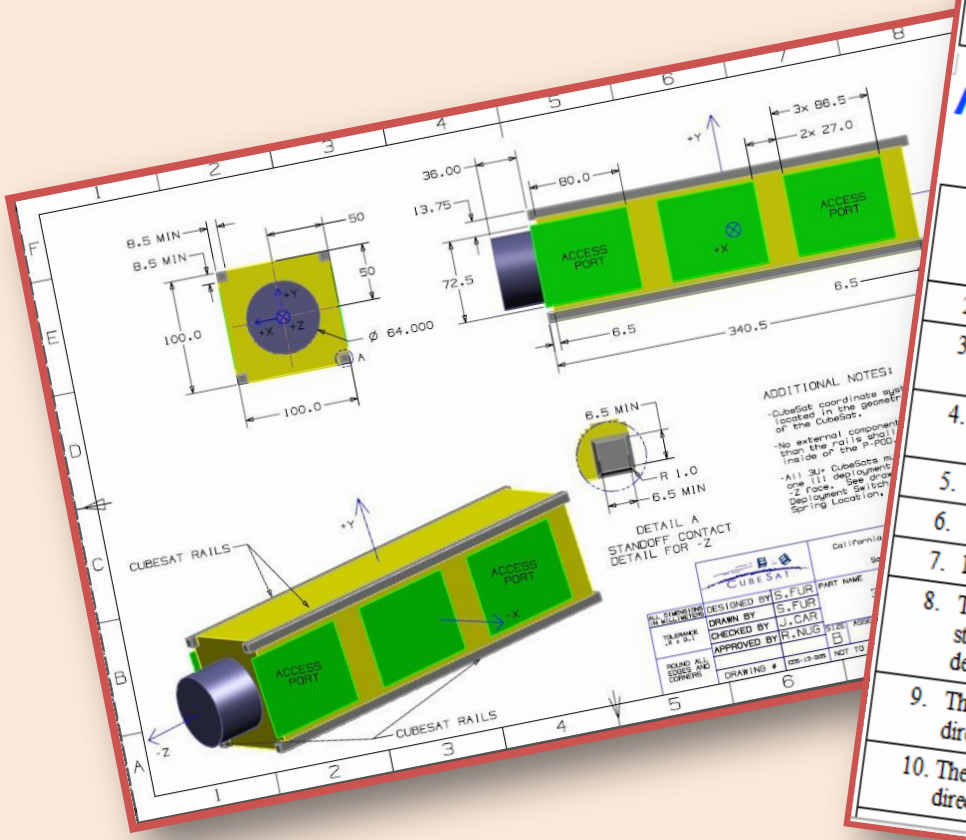
Nicolas HEIM
Jordan DIBY
Edouard COLIN
Tristan MALLET
Robin KLAJZYNGIER
Juliette FOISSAUD
Lucas ORSATTO

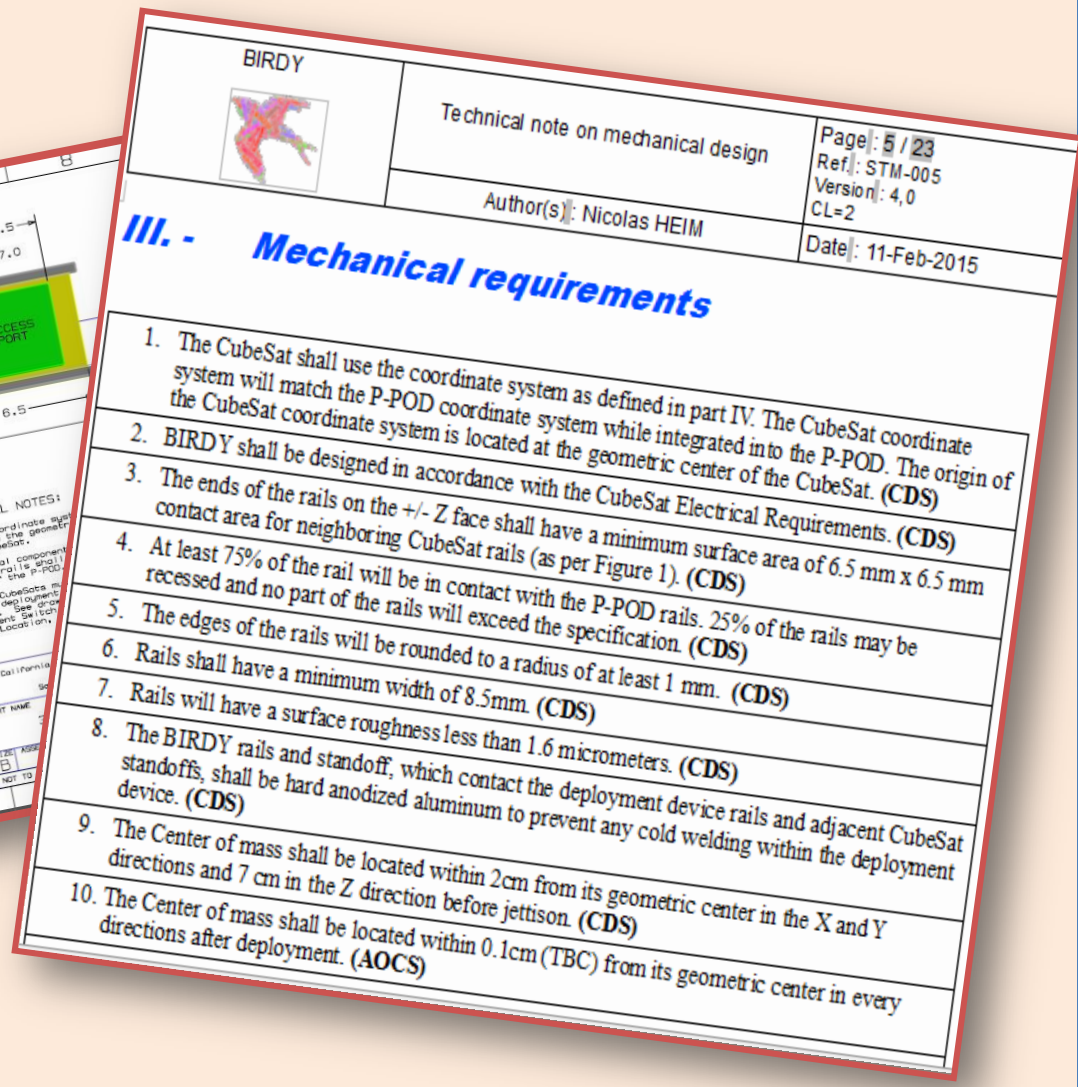
Conception – Pôle Mécanique

Design CATIA



Conception – Pôle Mécanique





BIRDY

Technical note on mechanical design

Page: 5 / 23
Ref: STM-005
Version: 4,0
CL=2

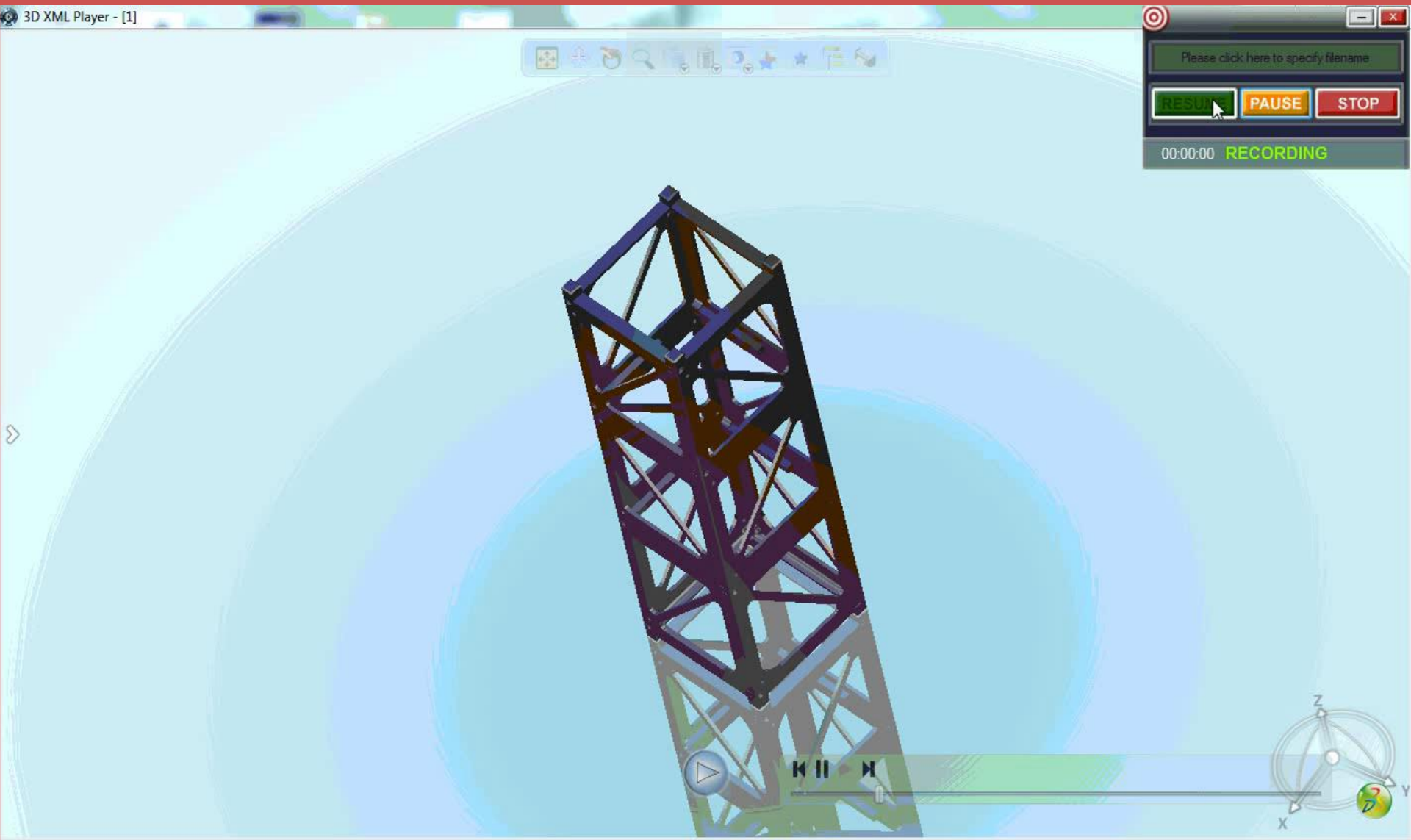
Author(s): Nicolas HEIM

Date: 11-Feb-2015

III. - Mechanical requirements

1. The CubeSat shall use the coordinate system as defined in part IV. The CubeSat coordinate system will match the P-POD coordinate system while integrated into the P-POD. The origin of the CubeSat coordinate system is located at the geometric center of the CubeSat. **(CDS)**
2. BIRDY shall be designed in accordance with the CubeSat Electrical Requirements. **(CDS)**
3. The ends of the rails on the +/- Z face shall have a minimum surface area of 6.5 mm x 6.5 mm contact area for neighboring CubeSat rails (as per Figure 1). **(CDS)**
4. At least 75% of the rail will be in contact with the P-POD rails. 25% of the rails may be recessed and no part of the rails will exceed the specification. **(CDS)**
5. The edges of the rails will be rounded to a radius of at least 1 mm. **(CDS)**
6. Rails shall have a minimum width of 8.5mm. **(CDS)**
7. Rails will have a surface roughness less than 1.6 micrometers. **(CDS)**
8. The BIRDY rails and standoff, which contact the deployment device rails and adjacent CubeSat standoffs, shall be hard anodized aluminum to prevent any cold welding within the deployment device. **(CDS)**
9. The Center of mass shall be located within 2cm from its geometric center in the X and Y directions and 7 cm in the Z direction before jettison. **(CDS)**
10. The Center of mass shall be located within 0.1cm (TBC) from its geometric center in every directions after deployment. **(AOCS)**

Conception – Pôle Mécanique



Conception – Pôle Mécanique

IDM-CIC pré-dimensionnement

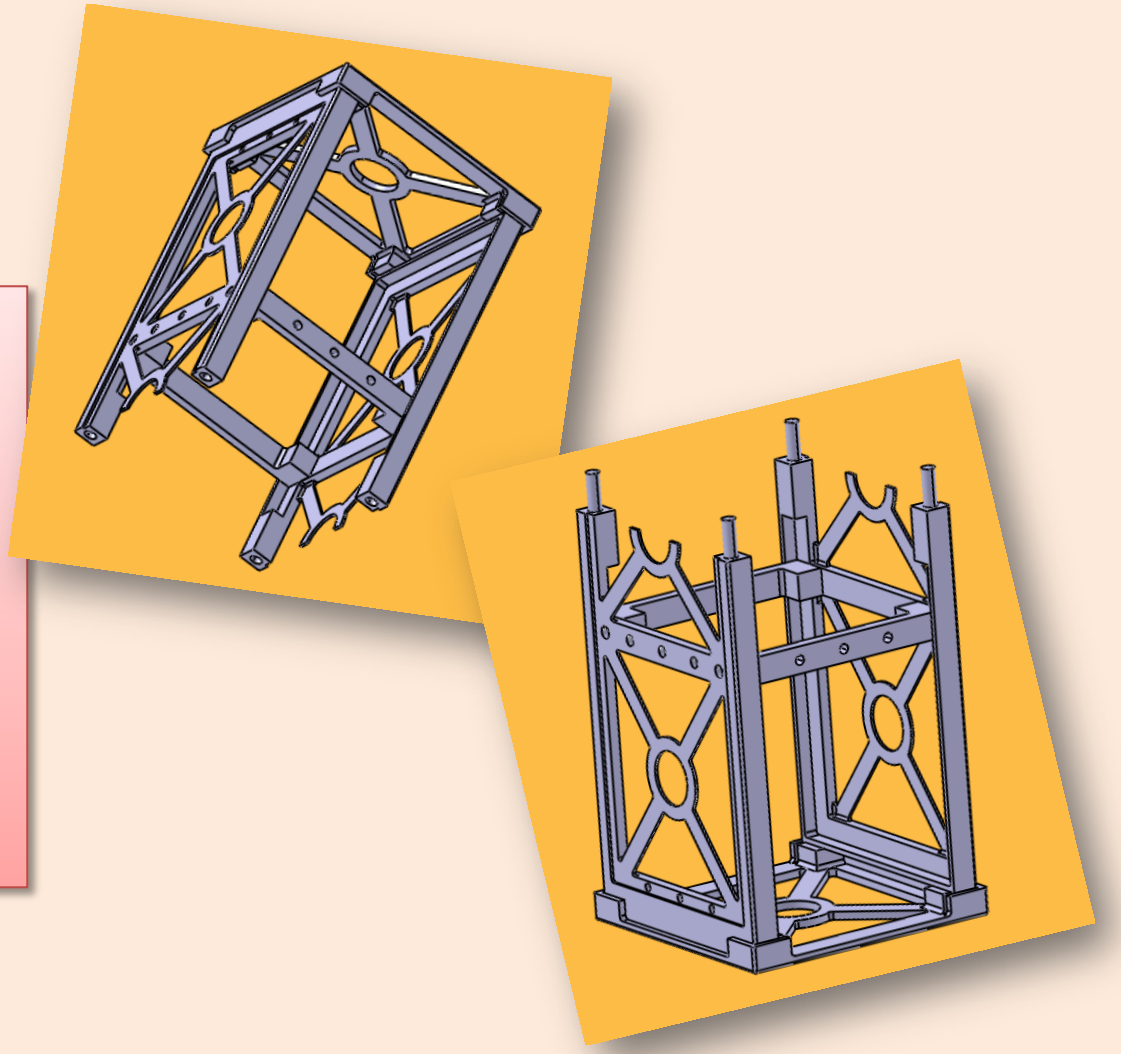
Database Ref.	COG [mm]			Inertia matrix at equipment COG [KG.M²]					
	x	y	z	xx	xy	xz	yy	yz	zz
	0	0	0	0	0	0	0	0	0
	-2,7019	12,962	1,758E-12	0,0009161	-1,33E-06	0	0,0008459	-9,31E-07	7,103E-05
	0,5	0,002	-3,03E-17	0,0007942	0	0	0,0007381	0	5,609E-05
	,0003249	0,0003249	0,3	1,246E-05	0	0	1,246E-05	0	2,492E-05

- Centraliser l'information.
- Dimensionner (CoM, CoI, Mass budget…).
- Offrir un visuel.

Conception – Pôle Mécanique

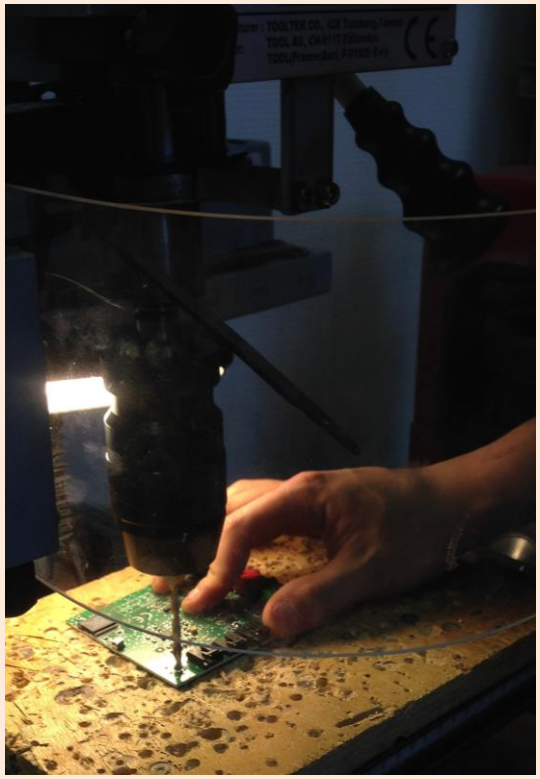
Impression 3D

- Objet manipulable, permet de confronter le modèle numérique au réel.
- Valide ou non les choix de conception/montage.
- Support de communication.



AIT/AIV – Pôle Mécanique

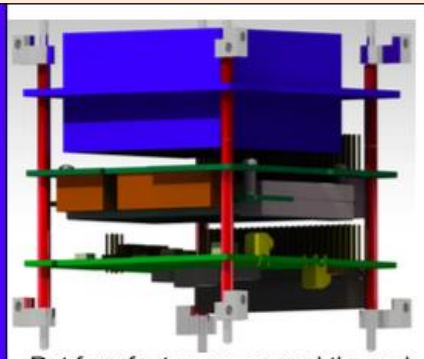
Système d'assemblage



AIT / AIV – Tests vibratoires

Procédure d'intégration

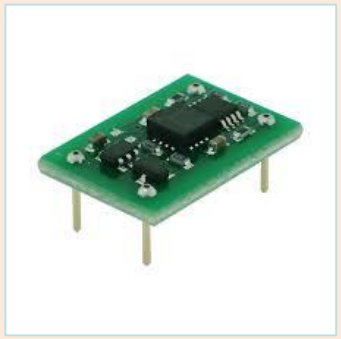
Tests pré-assemblage → Assemblage & intégration → Test post-assemblage

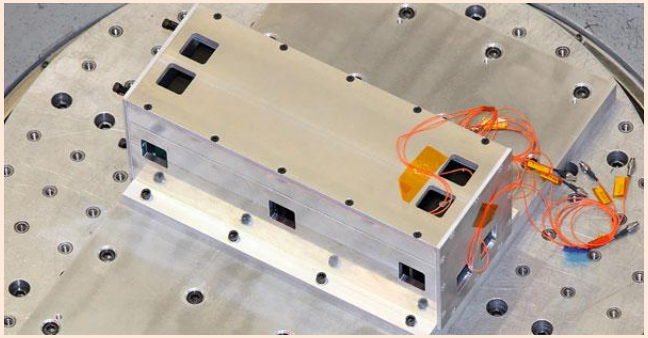
11	 Put four fasteners around the rod and check that they are on the same plan like on the picture.	Four fasteners well screwed and located on the same plan.
12	Do the same with the 3 units (To be completed with the progress of the other teams)	
13	 Fix a frame 1 with a frame 2 (screwing) 2 times	Frames fixed

AIT / AIV – Tests vibratoires

❑ ***Mise en place***

- ***Fixation des accéléromètres***
- ***Installation sur pot vibrant par l'intermédiaire d'un test-pod***





AIT / AIV – Tests vibratoires

❑ *Evolution des tests*

Vibrations sinusoïdales

- Mesure de la réponse
- Relevé de la fréquence propre
- Mesures fonctionnelles

Vibrations aléatoires contrôlées

- Mesure de la réponse
- Mesures fonctionnelles

Vibrations sinusoïdales

- Comparer la réponse avec la premi
- Mesures fonctionnelles

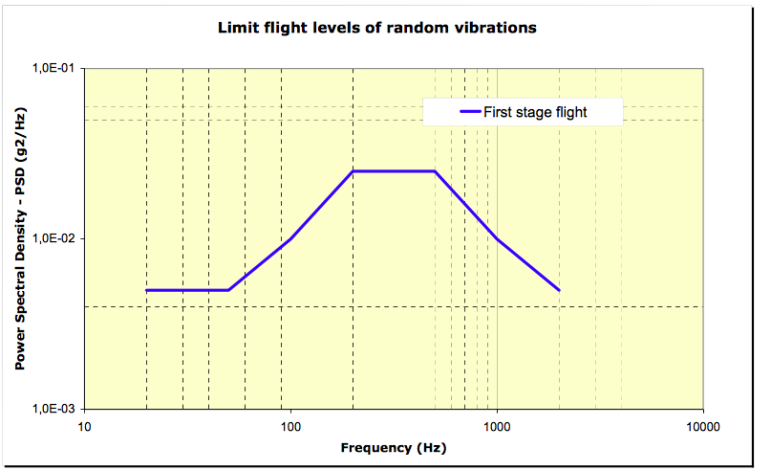
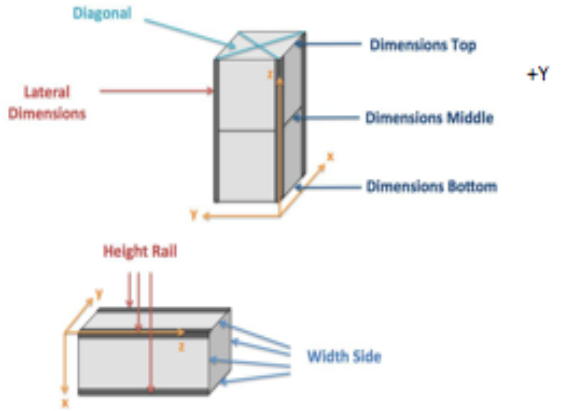


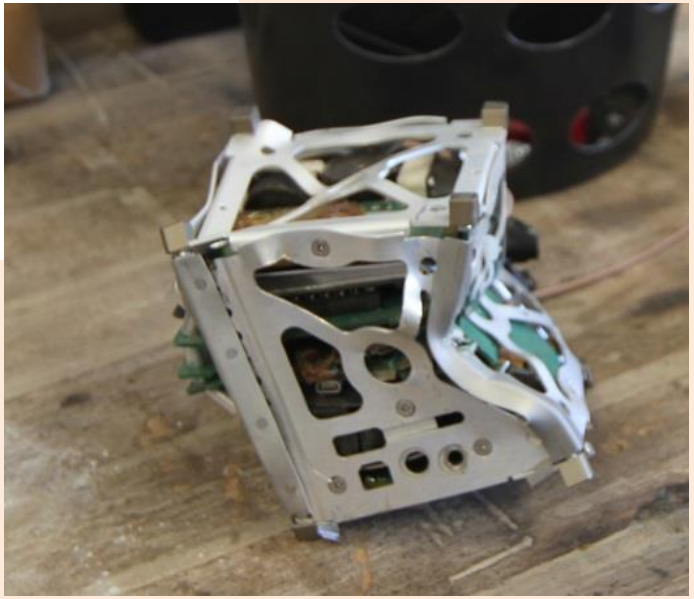
Figure 3.2.5a – Random vibration at spacecraft base (first stage flight)

AIT / AIV – Tests vibratoires

List Item	Actual	Required
Mass	_____	$\leq 4000g$
Remove Before Flight	_____	Protrudes $\leq$ 6.5 mm
Spring Plungers	_____	Option (A/B) Functional (Y/N)
Rails	_____	Anodized (Y/N)
Deployment Switches	_____	Option (A/B) Functional (Y/N)
Width [x-y], Top		
Side 1	_____	$100.0 \pm 0.1mm$
Side 2	_____	$100.0 \pm 0.1mm$
Side 3	_____	$100.0 \pm 0.1mm$
Side 4	_____	$100.0 \pm 0.1mm$



List Item	Actual	Required
Height [z]		
Rail 1	_____	
Rail 2	_____	
Rail 3	_____	



AIT / AIV – Tests vibratoires

❑ ***Les résultats***

- Comparaison des fréquences de résonance avec celles déterminées sur Catia

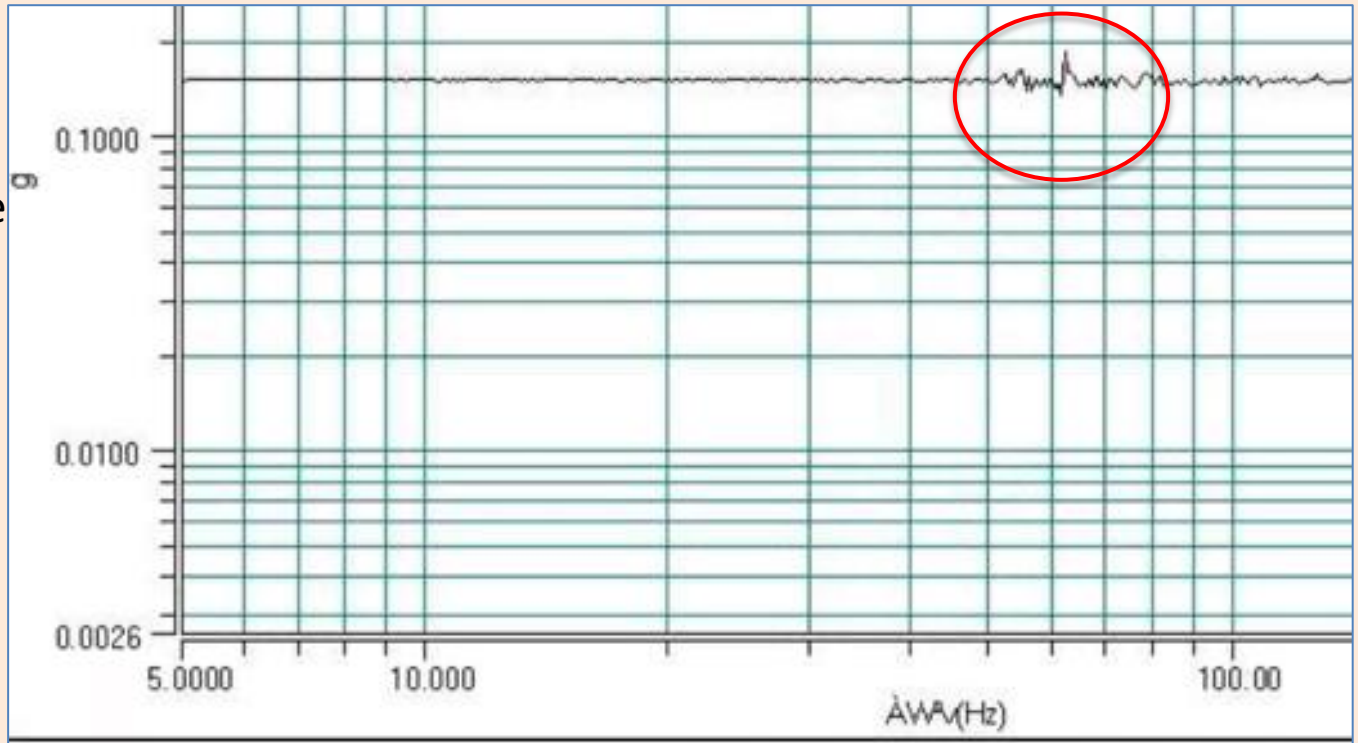


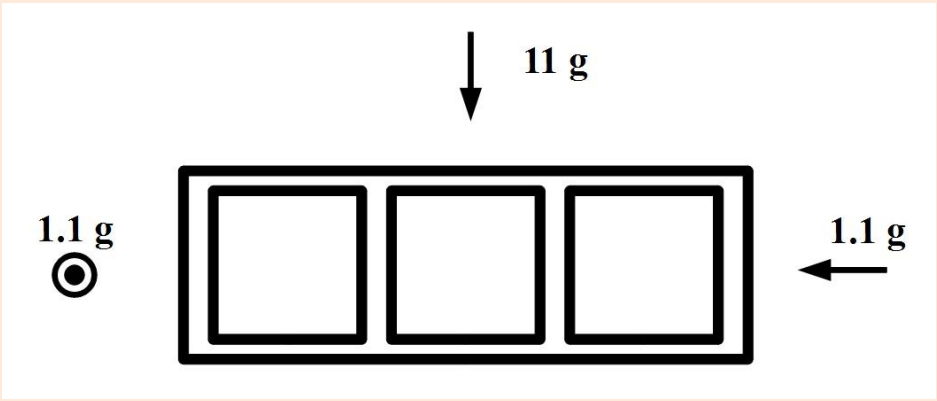
Figure 11 - Y-axis signature test #2

FEA – Pôle Mécanique

Objectifs

Earth	Launch	Space
Temperature	Acoustic loads	Temperature
Moisure	**Quasi static loads**	Therma flux
	Dynamic loads	Vacuum / Outgassing
	Shock loads	Radiations
		Atomic oxygen

Environmental factors taken into account when designing the CubeSat



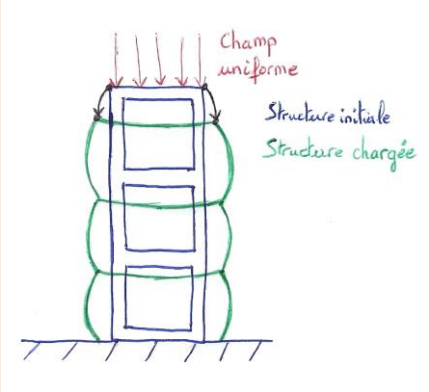
Champ axial max :11g
Champ longitudinal max : 1,1

➔ Champ max testé dans toutes les directions : 11 g

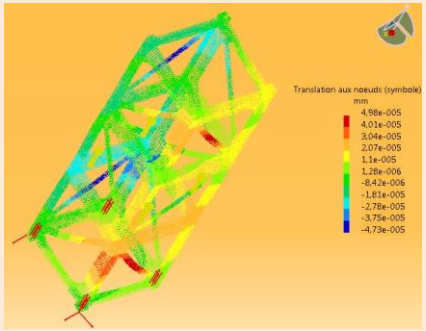
FEA – Pôle Mécanique

Démarche FEA

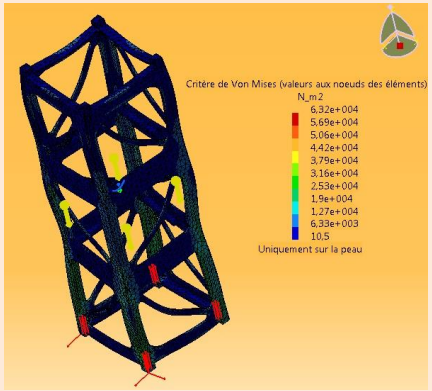
Prévision du champ de déplacement

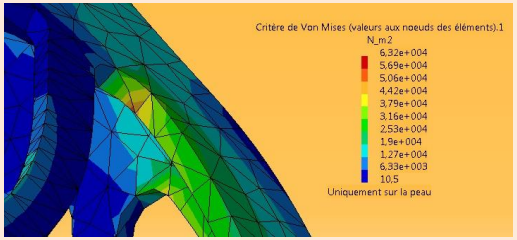


Conditions aux limites
➔ Champ de déplacement cohérent



Charge appliquée à la structutre



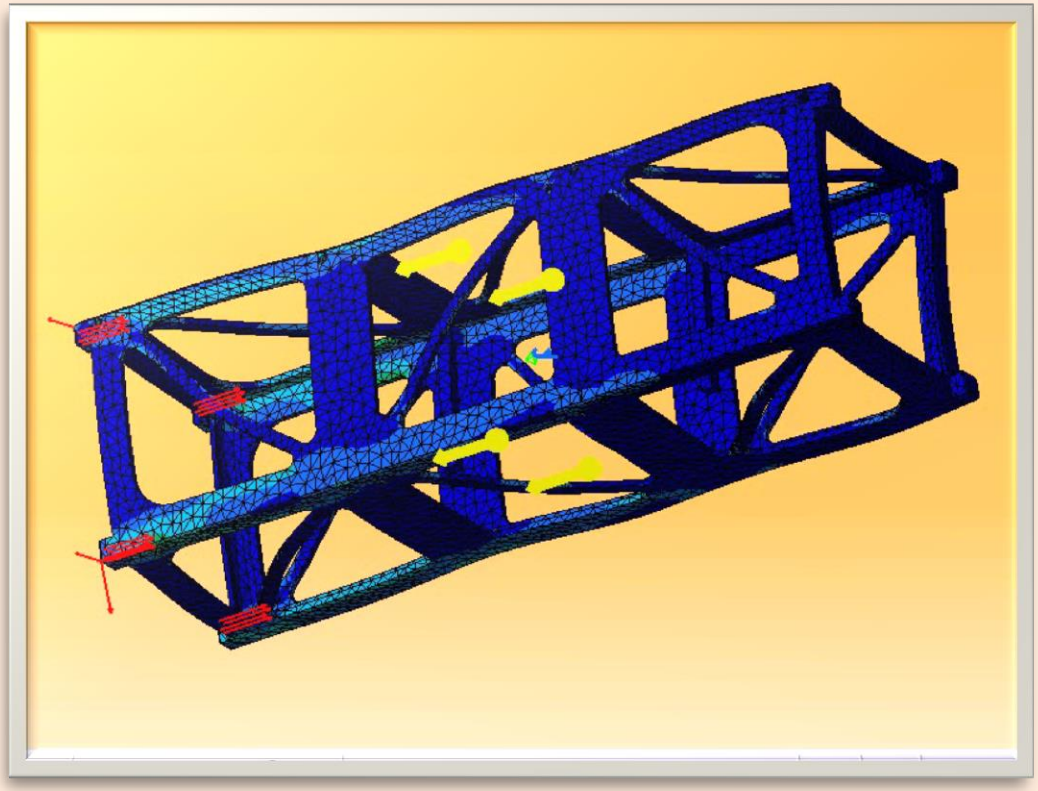


➔Interpréter les résultats
➔Apporter des modifications

FEA – Pôle Mécanique

Résultats et interprétations

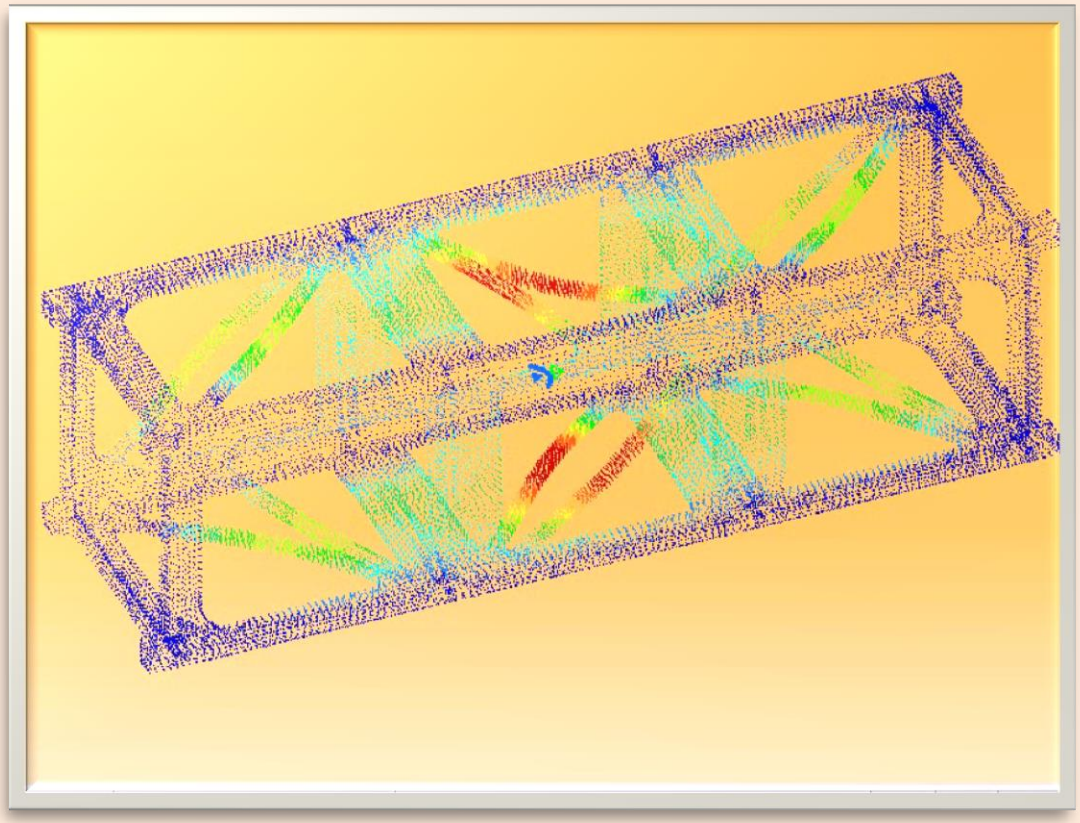
- Contrainte max : 63 kN
- Déplacement max : 5 e-5 mm



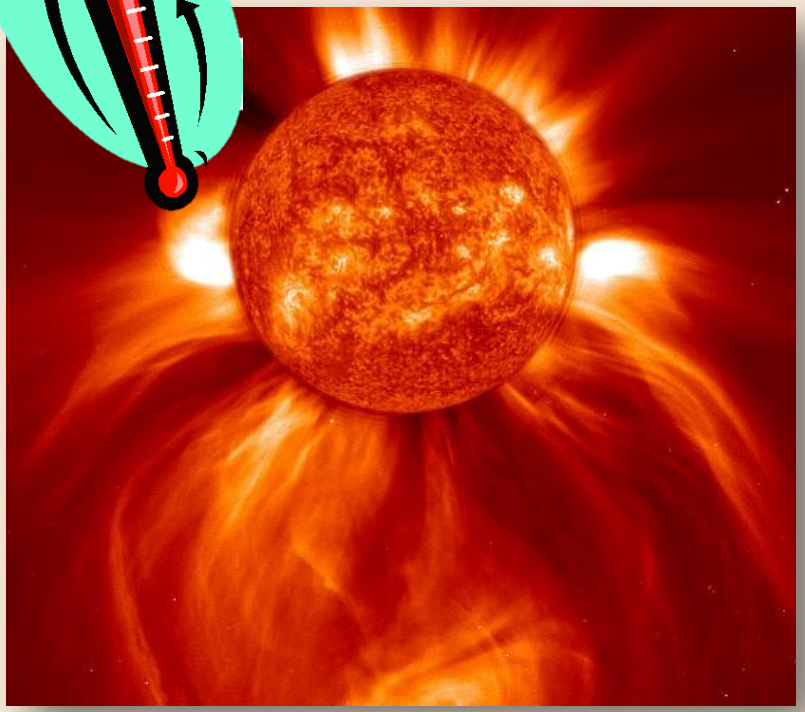
FEA – Pôle Mécanique

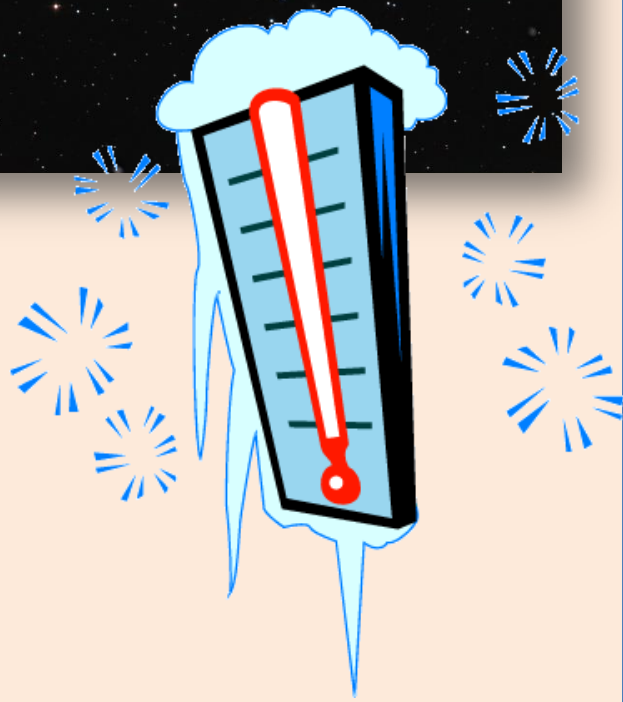
Analyse modale

- Modes propres
- Déformation associée à chaque mode propre



Le Pôle thermique

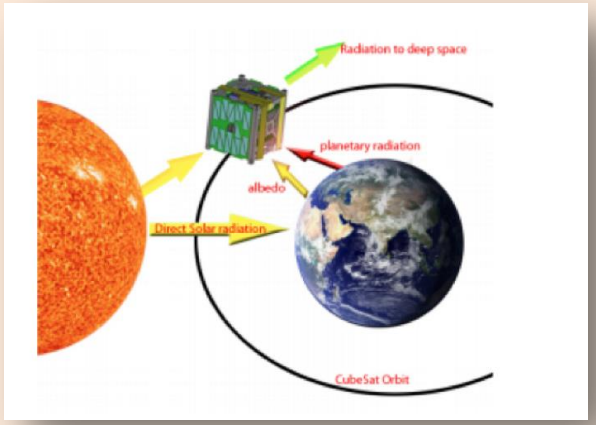




Quel Environnement ?

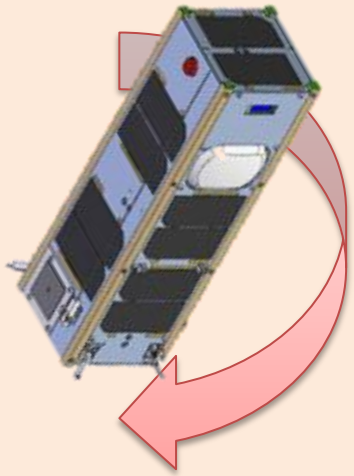
Hostile

- -270°C isolé
- Radiations solaires
- Radiations Planètes
- Albedos



Variable

- Spin de BIRDY
- Trajectoire
- Dissipation interne



Le rôle du pôle thermique

But

- Modéliser le comportement thermique de BIRDY

Pourquoi ?

- Conseiller dans le choix des composants
- Orienter la disposition des sous systèmes

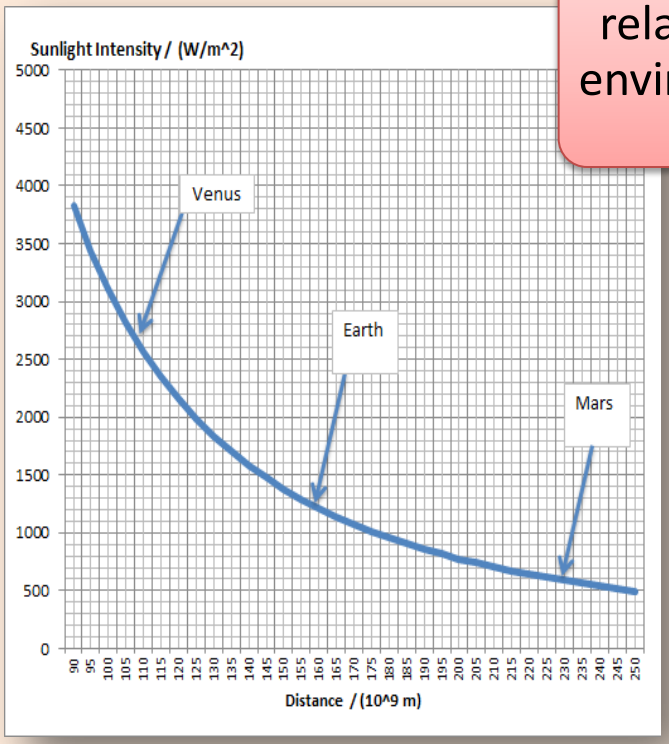
Comment

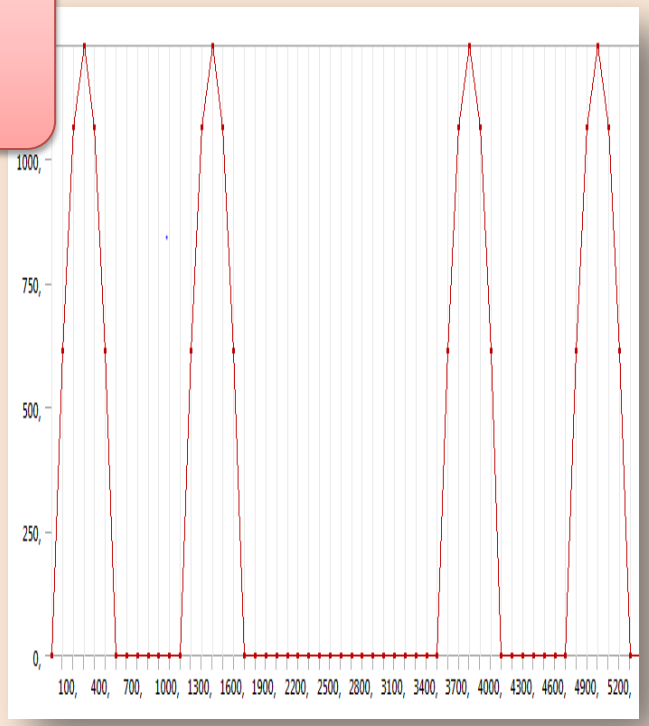
- En prévoyant les températures internes / externes
- En prévoyant la dilatation thermique

L'étude thermique

Position relative à son environnement

Son orientation (Spin)





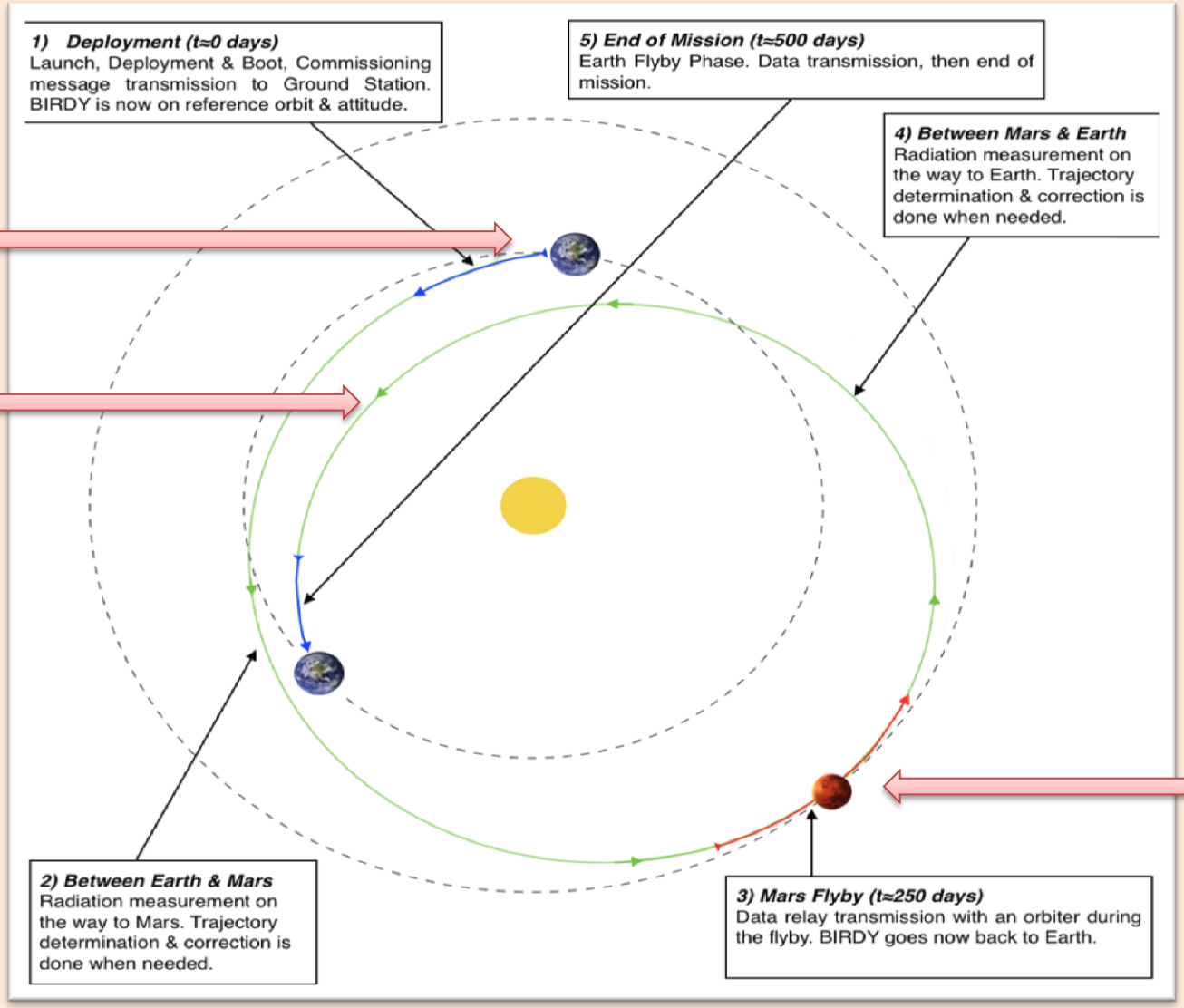
De nombreux cas possibles

4 cas extrêmes à prévoir

L'étude thermique

GTO Hot & Cold Case

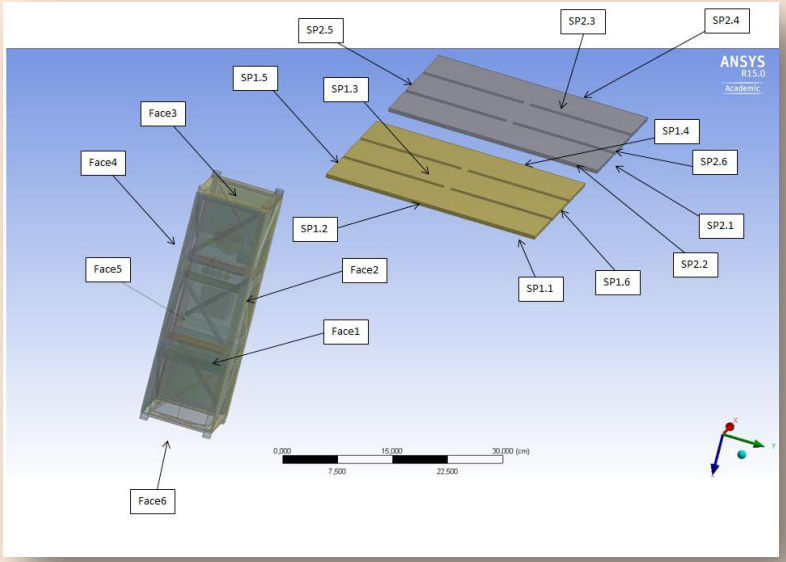
EME Hot Case

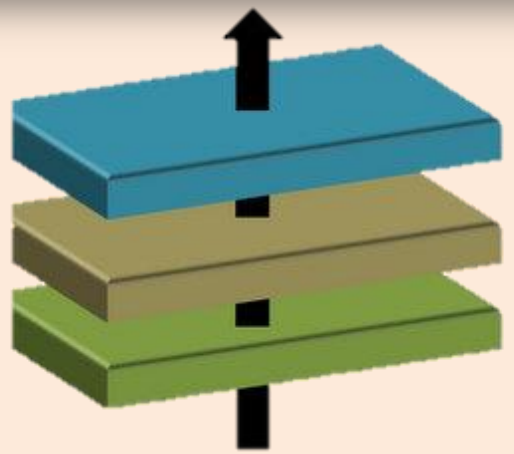


EME Cold Case

La simulation - ANSYS

- **Structure principale** reprise de l'étude mécanique
- **Panneaux solaires :**
  Matériau équivalent
  (uniformité thermique dans l'épaisseur)
- **Couplage thermique** pour simuler les jonctions délicates

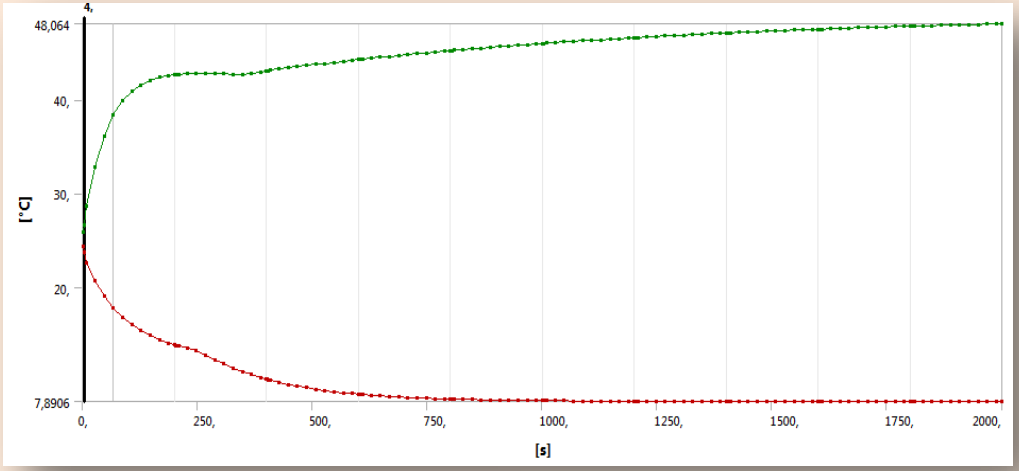


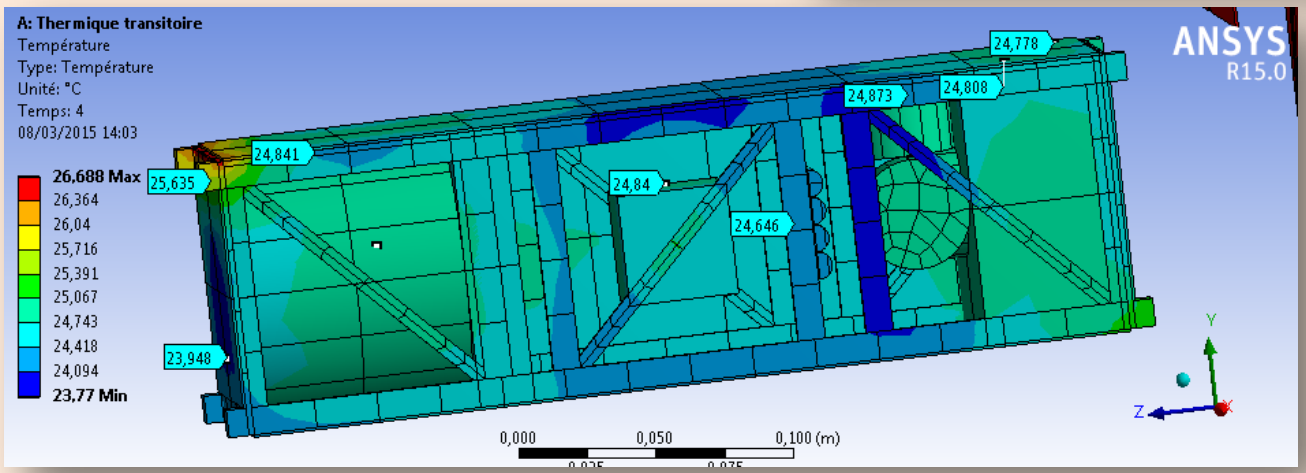


Exploitation des résultats

- **Températures globales**

  Exemple : GTO HOT CASE

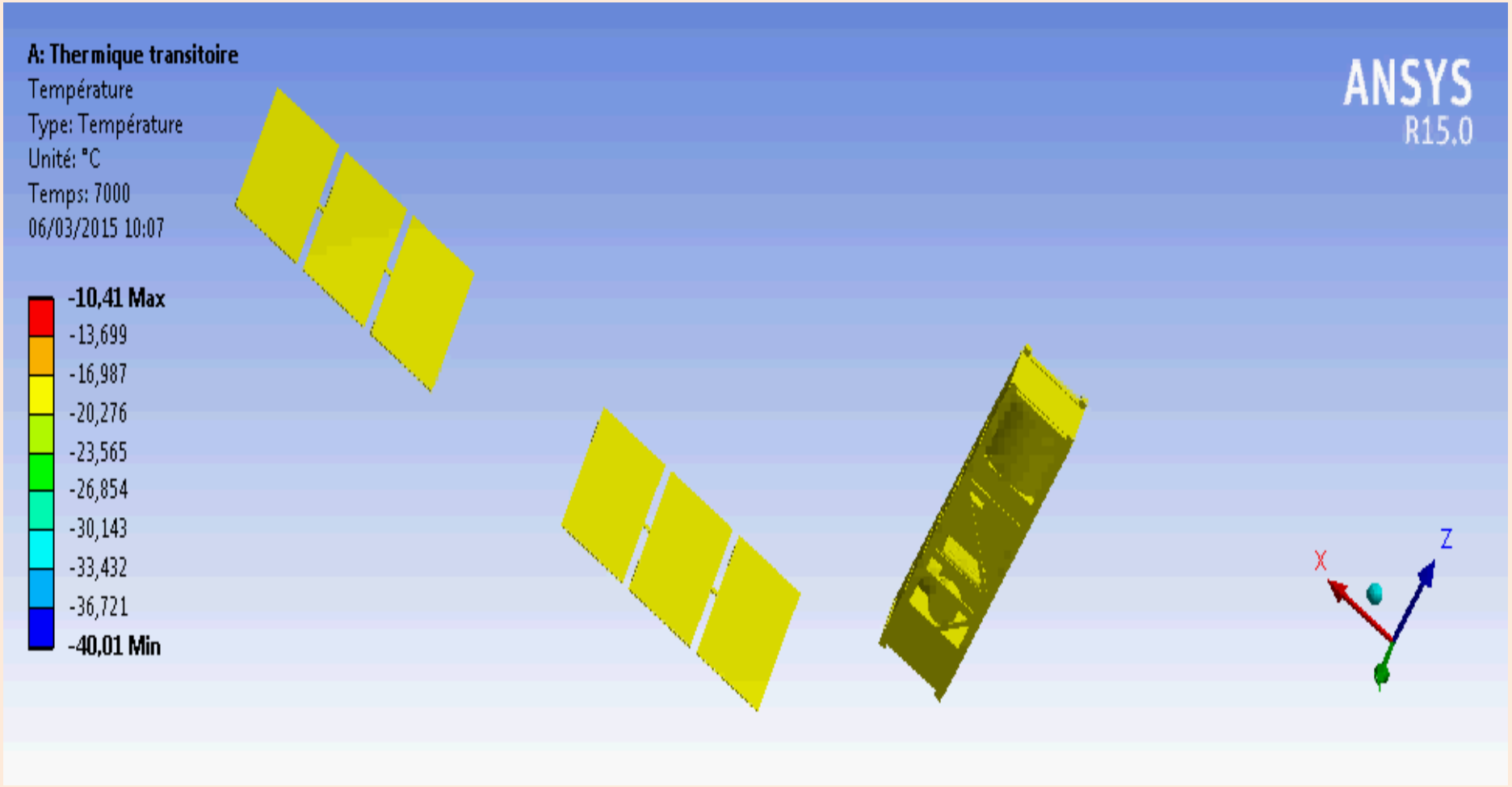




- **Températures locales**

Prédiction des températures extrêmes

Exploitation des résultats



Exploitation des résultats

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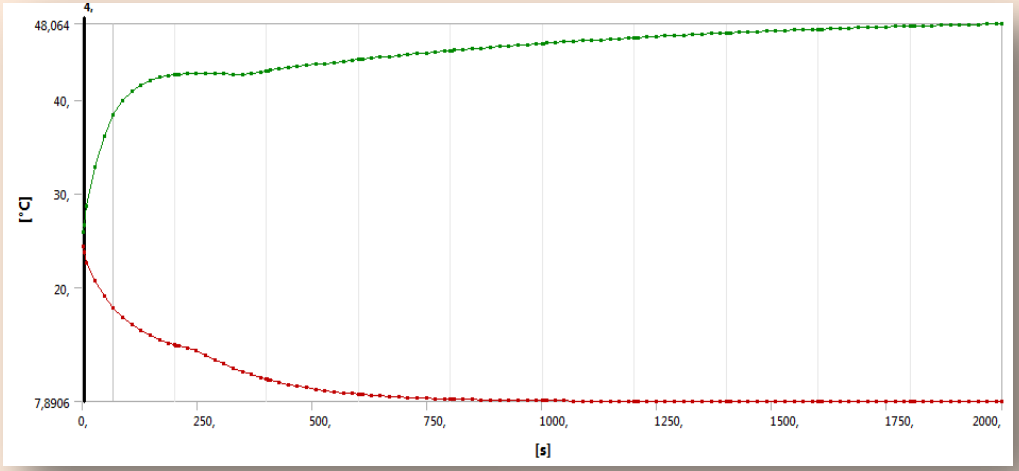
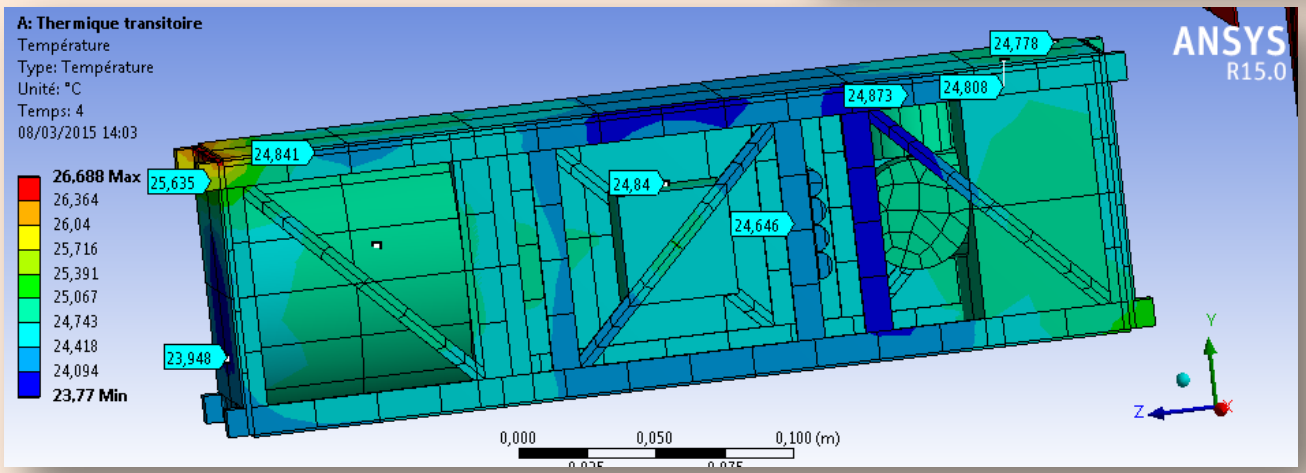
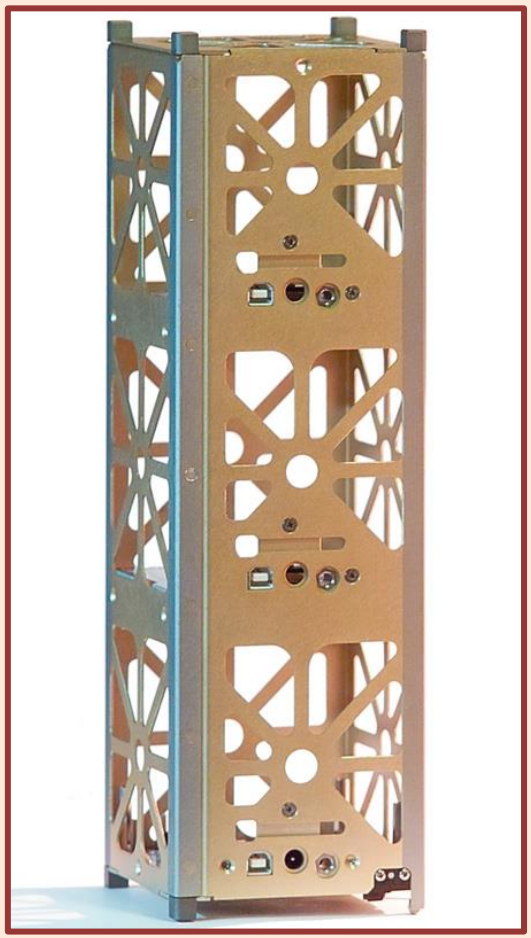


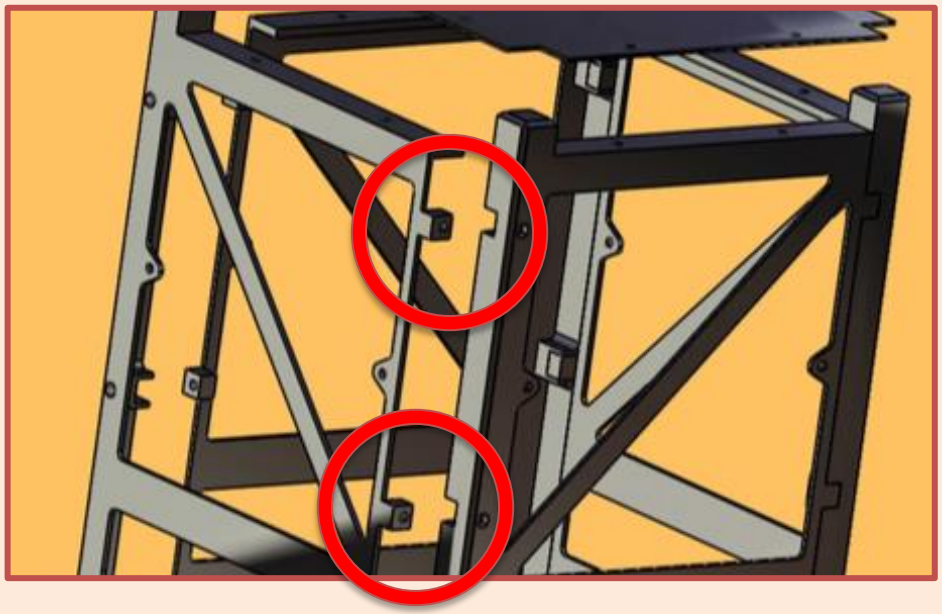


- **Températures locales**

Prédiction des températures extrêmes

Fabrication – Spécificités du Design





Cubesat Classique

- 4 tôles fines
- 4 tiges carrées

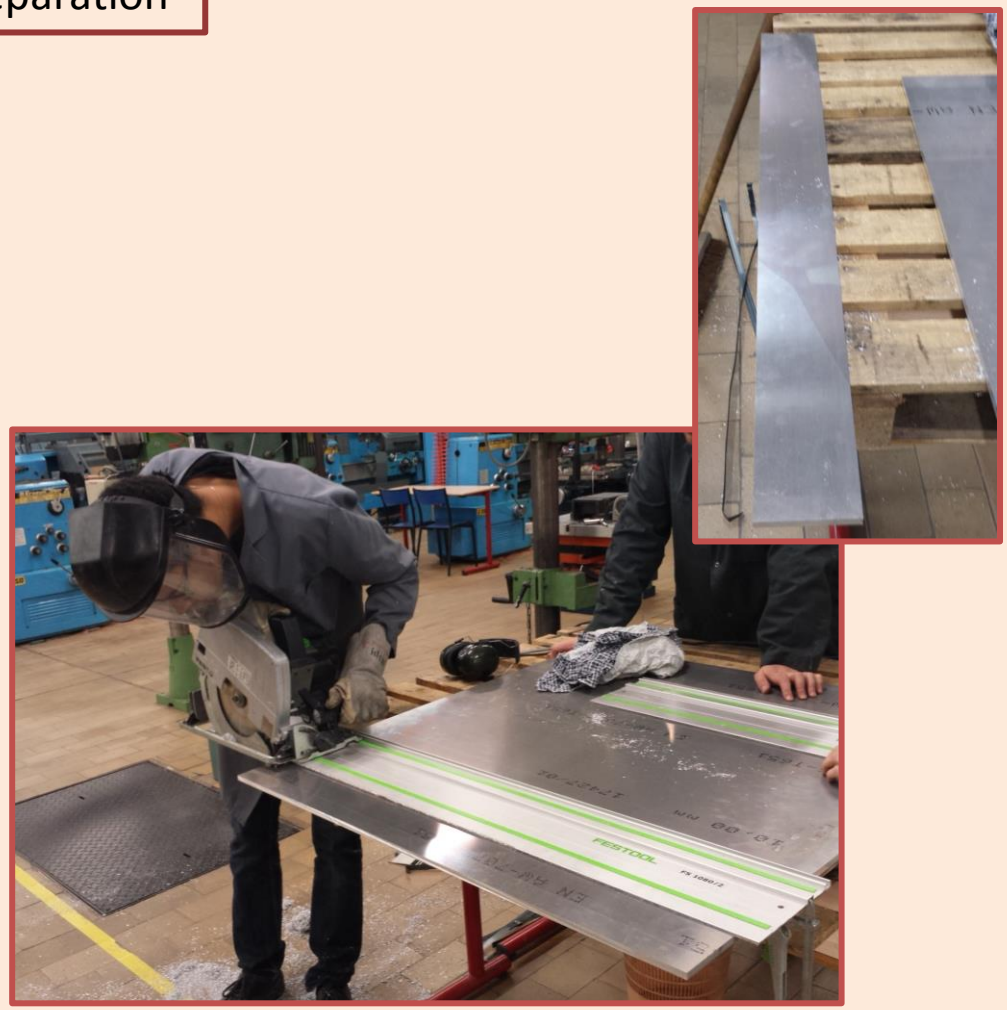
Cubesat BIRDY

- 4 Frames
- Liaisons par encastrement

Fabrication – Usinage

Première étape : Préparation

- Matériau : Aluminium 7075
- Pièce brute : 100 x 400 mm
- Machines
  - 3-axes commande numérique
  - Machine conventionnelle
- Logiciel : Module FAO CATIA V5



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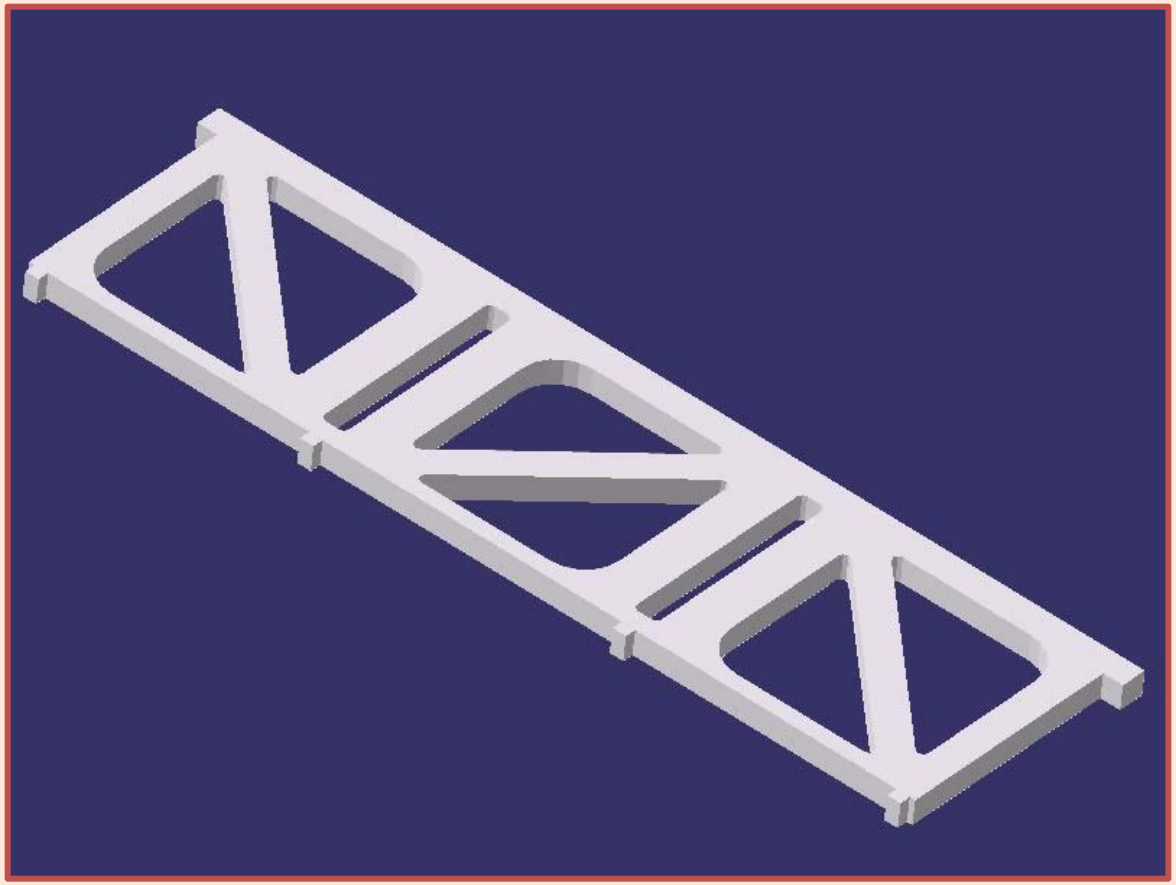
- Pièce brute : 100 x 400 mm
- Machines
  - 3-axes commande numérique
  - Machine conventionnelle
- Logiciel : Module FAO CATIA V5

Fabrication – Usinage

Deuxième étape : CN

- **2H30** : Gros œuvre : usinage des poches
- **0H30** : Phase de contournage
- **0H30** : Agrandissement des poches triangulaires
- **0H30** : Phase de précision : encastrements



Fabrication – Usinage

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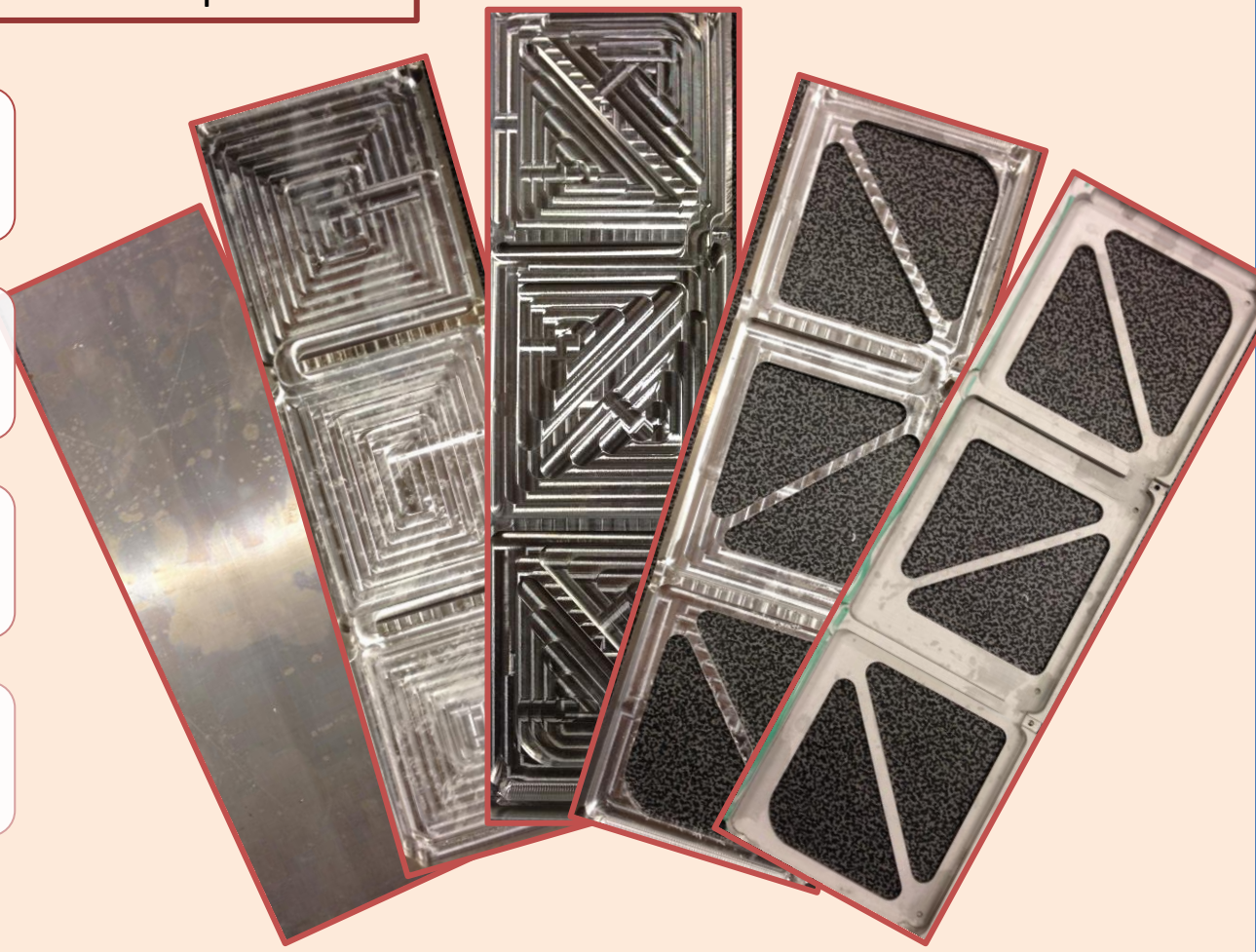
Fabrication – Usinage

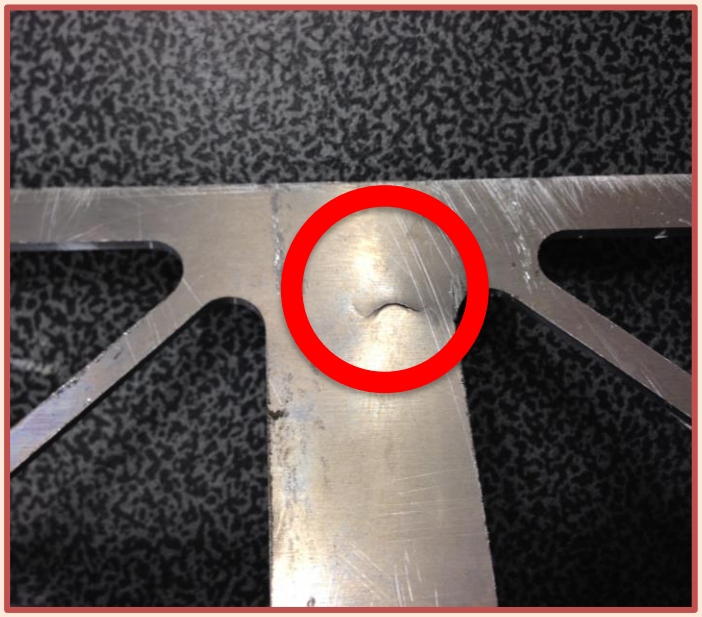
Deuxième étape : CN

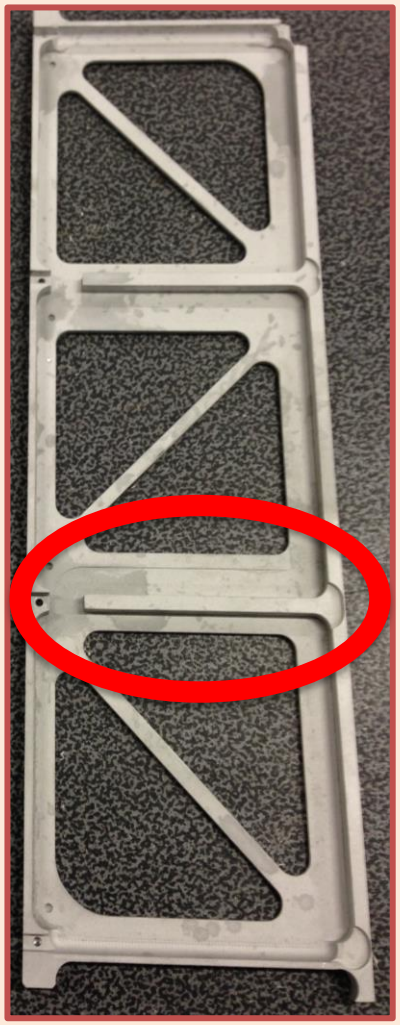
- **2H30** • Gros œuvre : usinage des poches
- **0H30** • Phase de contournage
- **0H30** • Agrandissement des poches triangulaires
- **0H30** • Phase de précision : encastrements



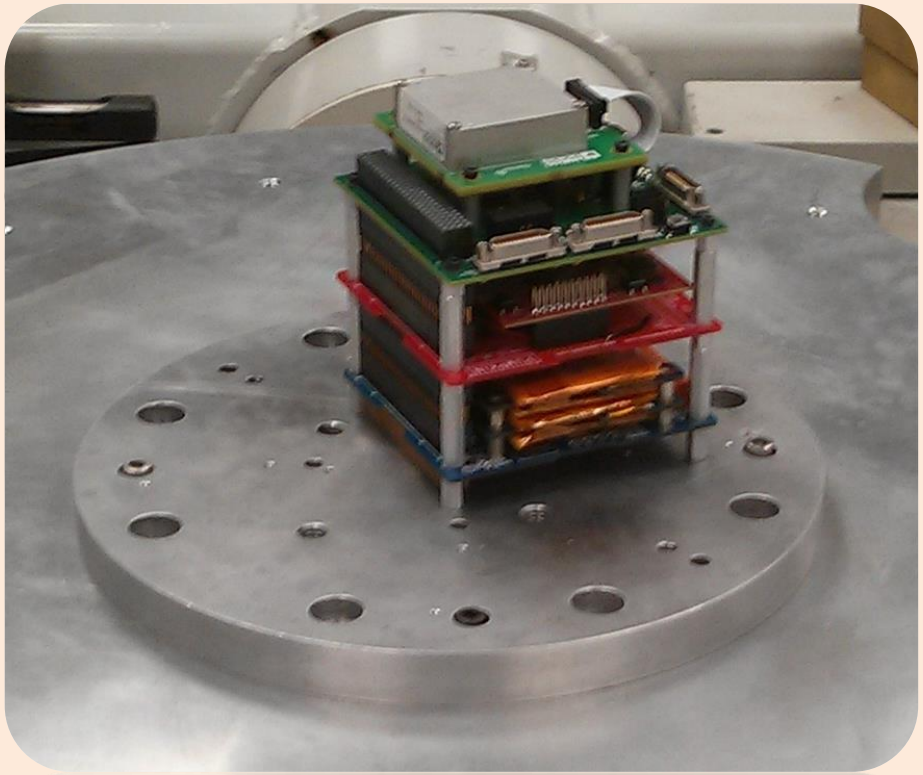
Fabrication – Limites du modèle

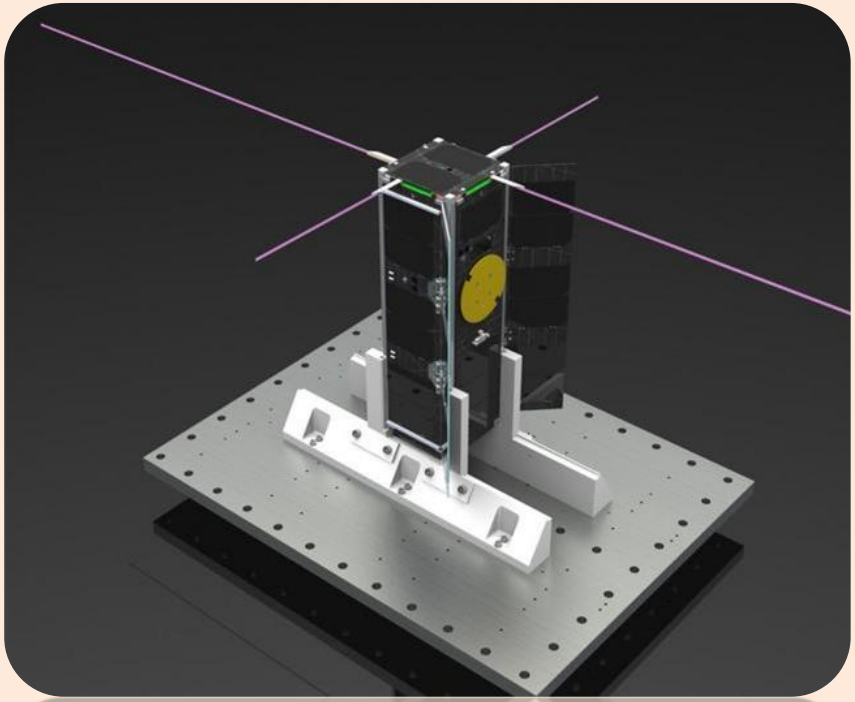
- Finesse de l'épaisseur finale des Frames
- Respect des contraintes internes du matériau
- Barre de renfort
- Epaisseur supérieure
- Compromis conception et fabrication : Mass Budget





Prochaine étape : les tests !





Merci de votre attention