Calculs linéairs sur l'Assemblage complet - approximé

Linear FEA of approximated Assembly

Distribution List :

LAM	Jean-Paul Baluteau		Kjetil Dohlen	
	Pascal Dargent	**X**	Michel Jevaud	
	Didier Ferrand	**X**	Patrick Levacher	
	Dominique Pouliquen	**X**		
MSSL	Berend Winter	**X**	John Coker	**X**

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LABORATOIRE D'**A**STROPHYSIQUE de **M**ARSEILLE - CNRS BP 8 13376 MARSEILLE Cedex 12 FRANCE
Tél : (33) +4 91 05 59 00 - Fax : (33) +4 91 05 69 59

1. Scope

This document gives preliminary results of statis and resonances behavior of the SMEC mechanism Assembly.

2. Softwares

The SMECm F.E.A. as been implemented with CosmosWorks 6.0 and CAD solid model constructed in SolidWorks2000 to get estimations of eigen frequencies, characteristic deformed shapes, and highest stresses under 100G loads.
This software package is limited to linear analysis, and doesn't allow volumic and shell elements merging.

3. Definition of parts

Only main structural parts (45) have been taken into account, for a total weight of 1440 grams. Ignored parts are mainly static (preamp, harness, etc..) and have very few impact on this analysis.

Definition of every part has been slightly simplified to avoid divergence of automatic meshing process.
Main modifications between CAD model and FEA model are :

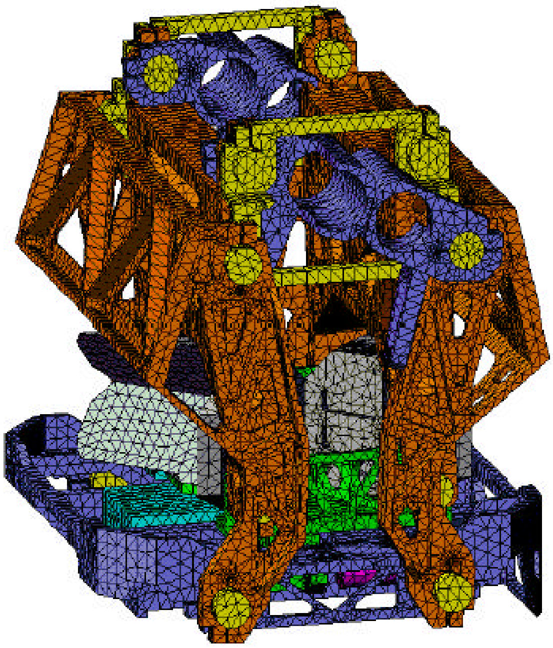
- Pivots have been replaced by homogeneous bulk parts with isotropic stiffness similar to pivot shear stiffness ***in non twisted position***. This rough simplification may affect results of calculations where torsion of pivots is solicited. Mass is preserved.
- Belts of synchronisation with 0.1 x 16 mm2 of section have been modeled as 0,4 x 4 mm2 short beams. Results of calculations where belts are bent will be affected.
- Latch has been simplified as plastic simple holds between actuator core and base structure. ***It doesn't take into account nonlinear behaviour of real latching*** due to few tens of microns of play in X, Y and Z directions.

BE System pivots have been modelised as simple rod of matter with $5 \cdot 10^9$ Pa modulus of elasticity, that would correspond approximately to a Nylon plastic reinforced with 30% of glass fibers. As comparison, 5016-800 TRW pivots, with lower shear stiffness for about the same torsion stiffness, would have been modelised by matter with $5 \cdot 10^8$ Pa modulus, i.e. a kind of Teflon.

All modulus are for materials at room temperature. 4K modulus are somewhat higher (about + 10% for aluminum), so frequencies will be under estimated, and static deflection over estimated.

4. Mesh

Meshing is automatic, and provides tetrahedral parabolique elements (TETRA10).
With SMECm we get 171190 elements, 52054 corner nodes, and 959115 D.O.F.



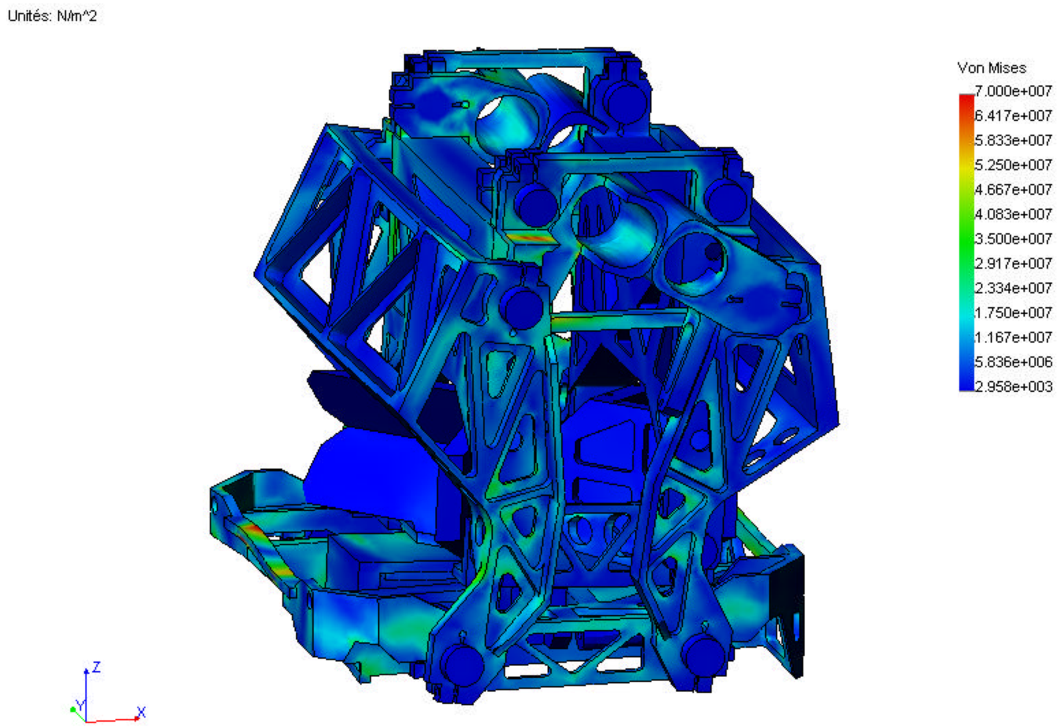
5. Latched Mechanism – Static loads

Static linear simulation have been done for 100 G acceleration in three main directions :

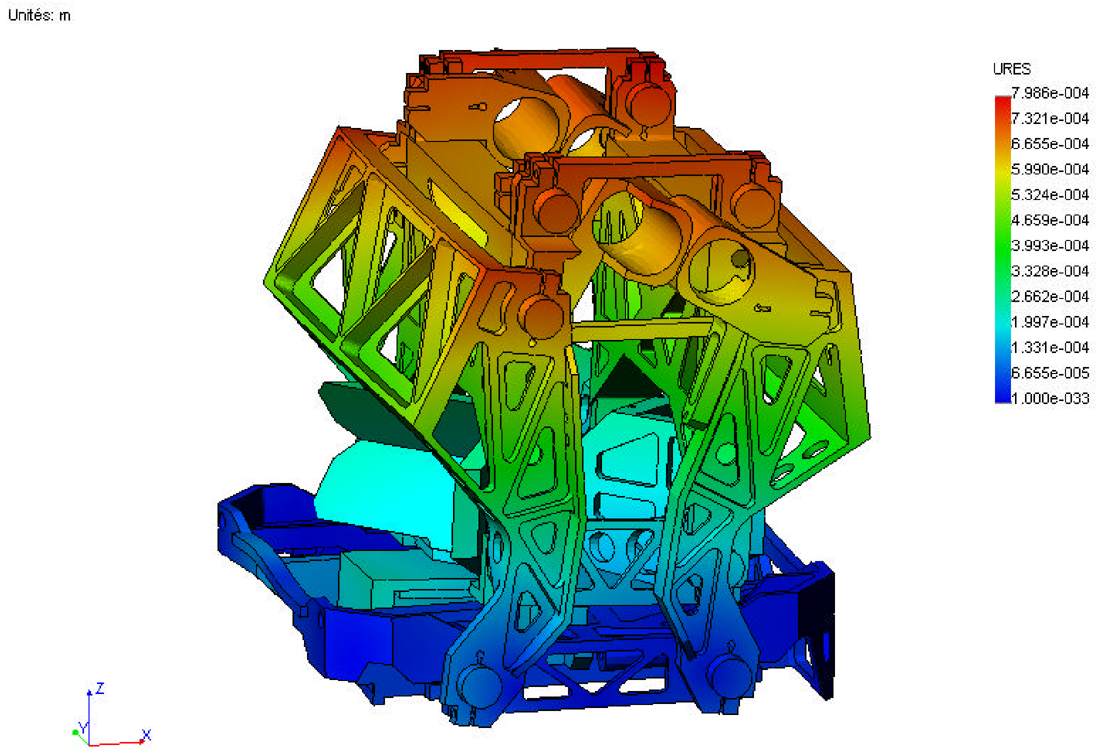
- Xm (parallele to mirrors movement)
- Ym (perpendicular to the bench)
- Zm (parallele rocking frames axis of rotation).

This analysis shows weakest sections of structural parts, and gives an estimation of maximal stress for all the assembly.

100 G in Xm :

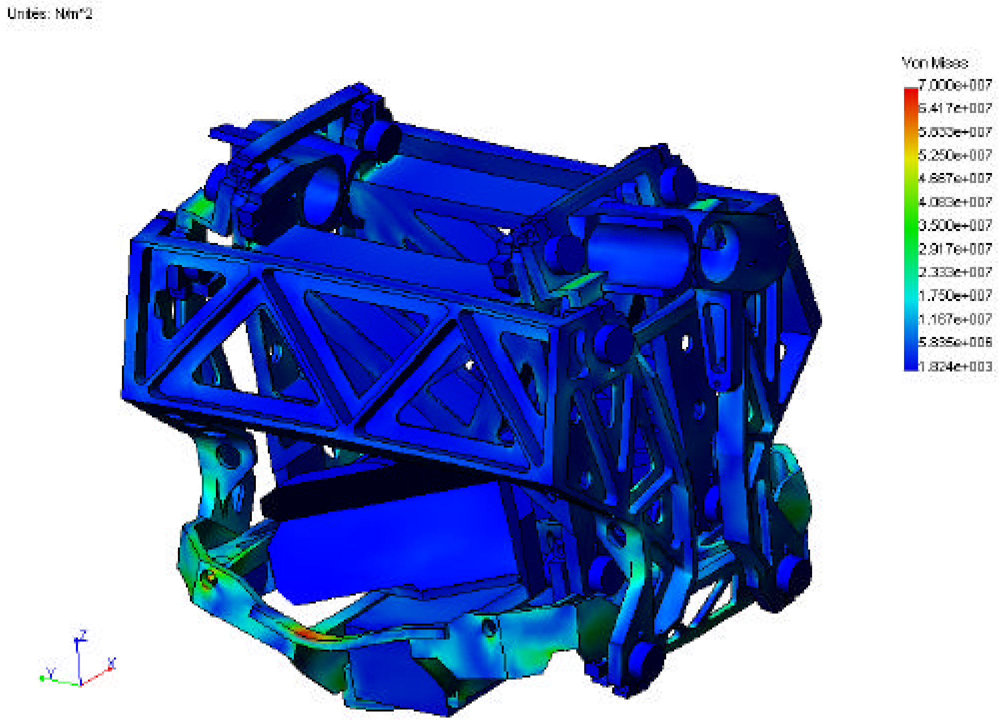


Highly solicited sections have been reinforced.
Maximal stress is 167 MPa

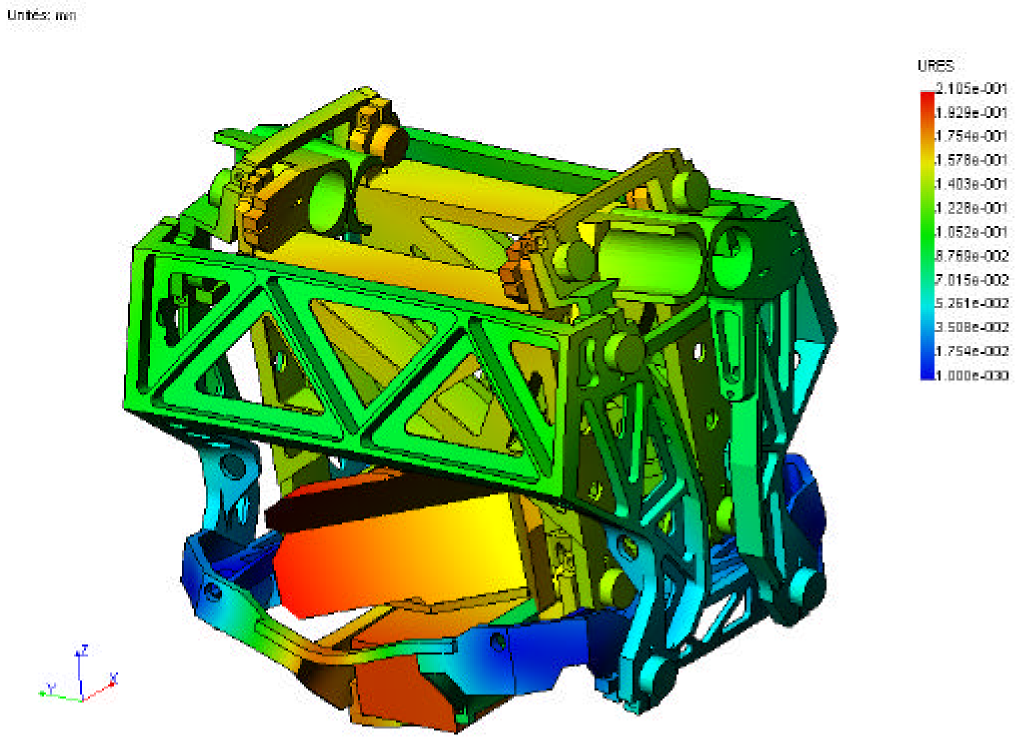


For 100G, maximal Longitudinal displacement is about 800 microns.

100 G in Ym :

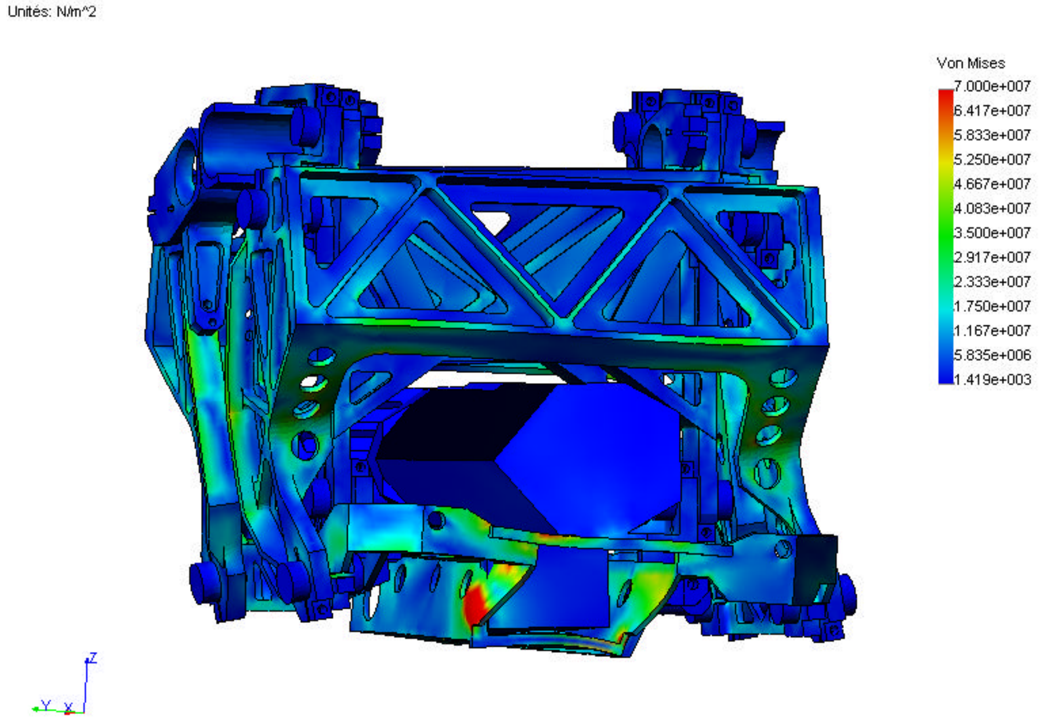


Highly solicited sections have been reinforced.
Maximal stress is 96 MPa

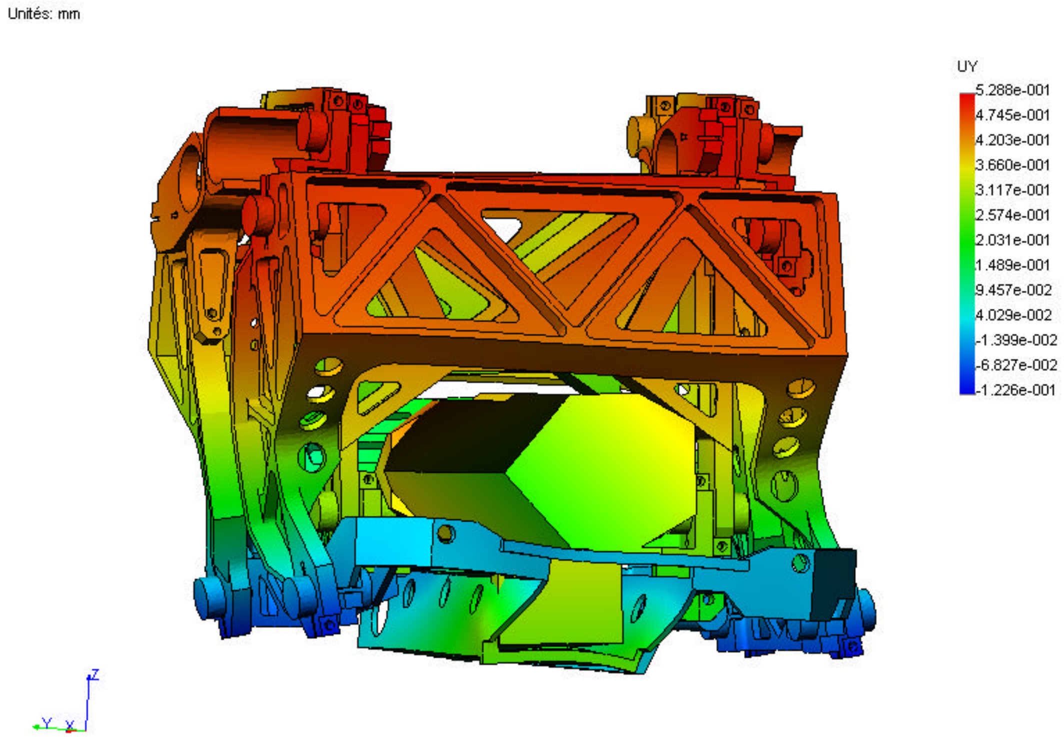


For 100G, maximal vertical displacement is about 210 microns.

100 G in Zm :



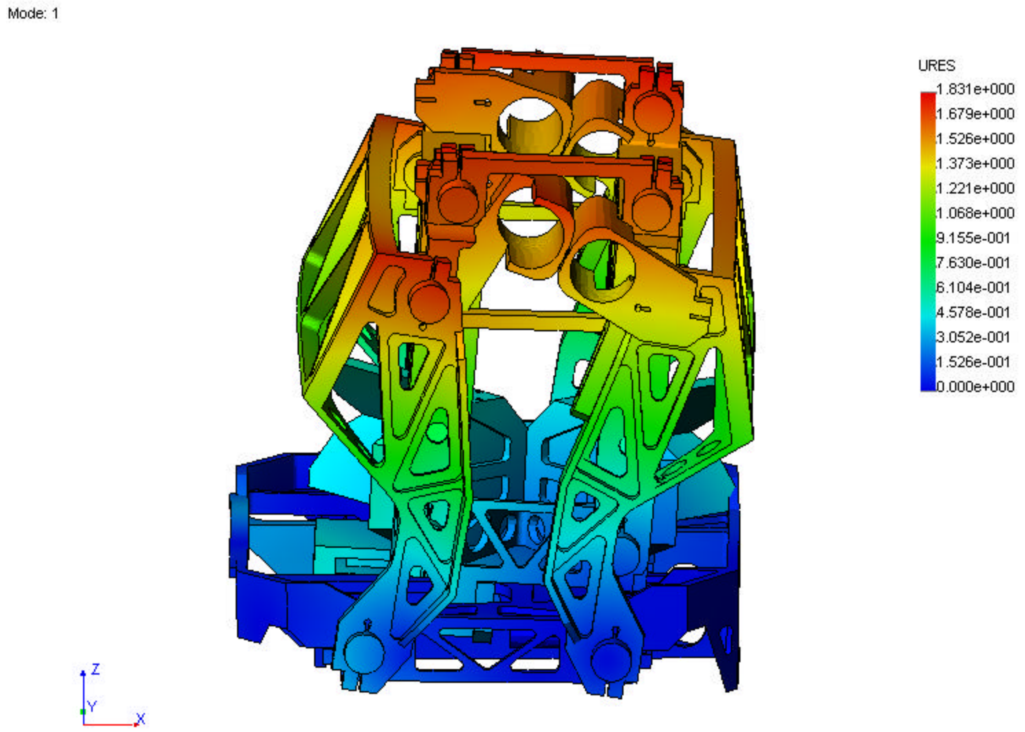
Highly solicited sections have been reinforced.
Maximal stress is 170 MPa



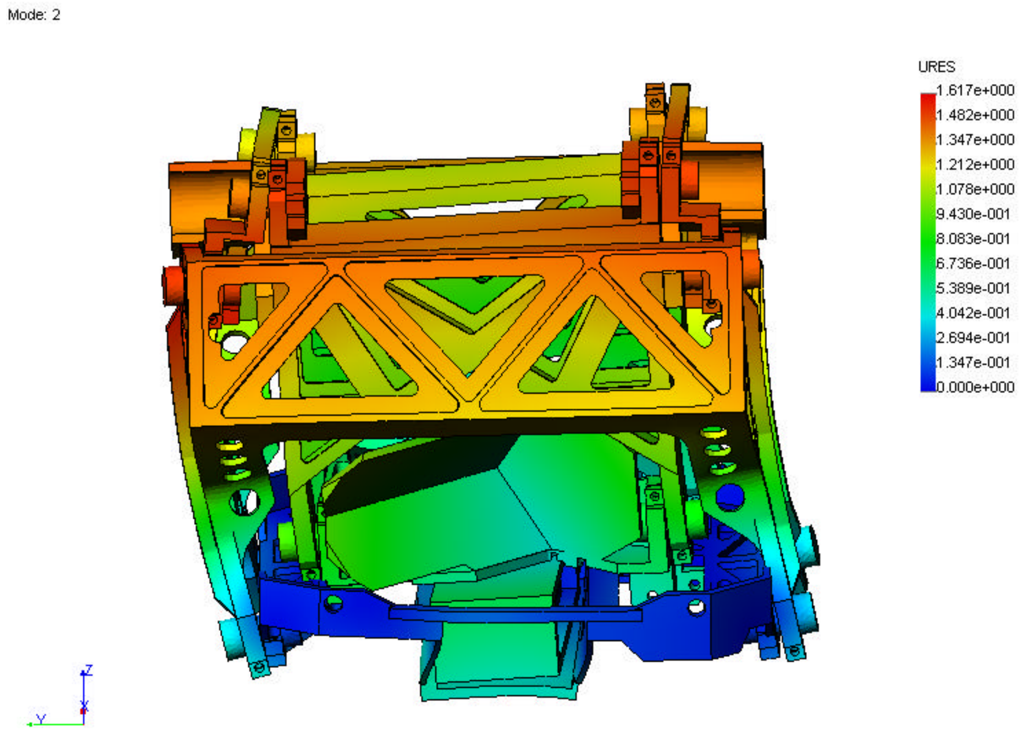
For 100G, maximal transversal displacement is about 530 microns.

6. Latched Mechanism – Eigen Frequencies

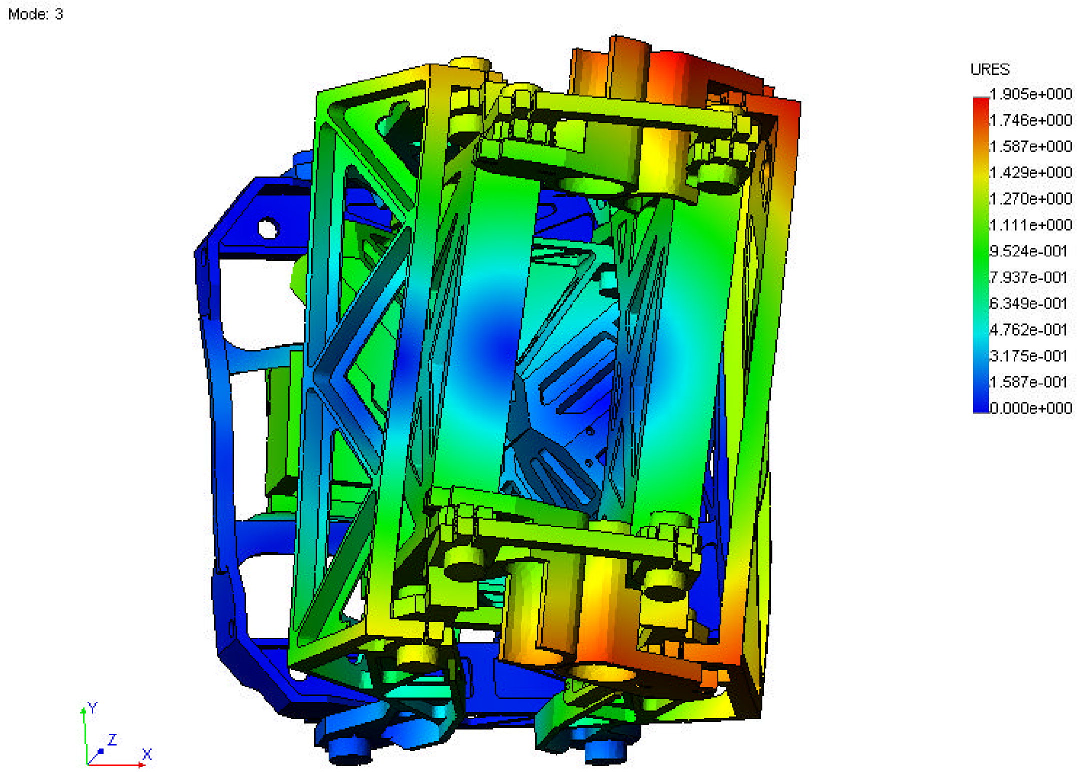
Number of modes was limited to 5.



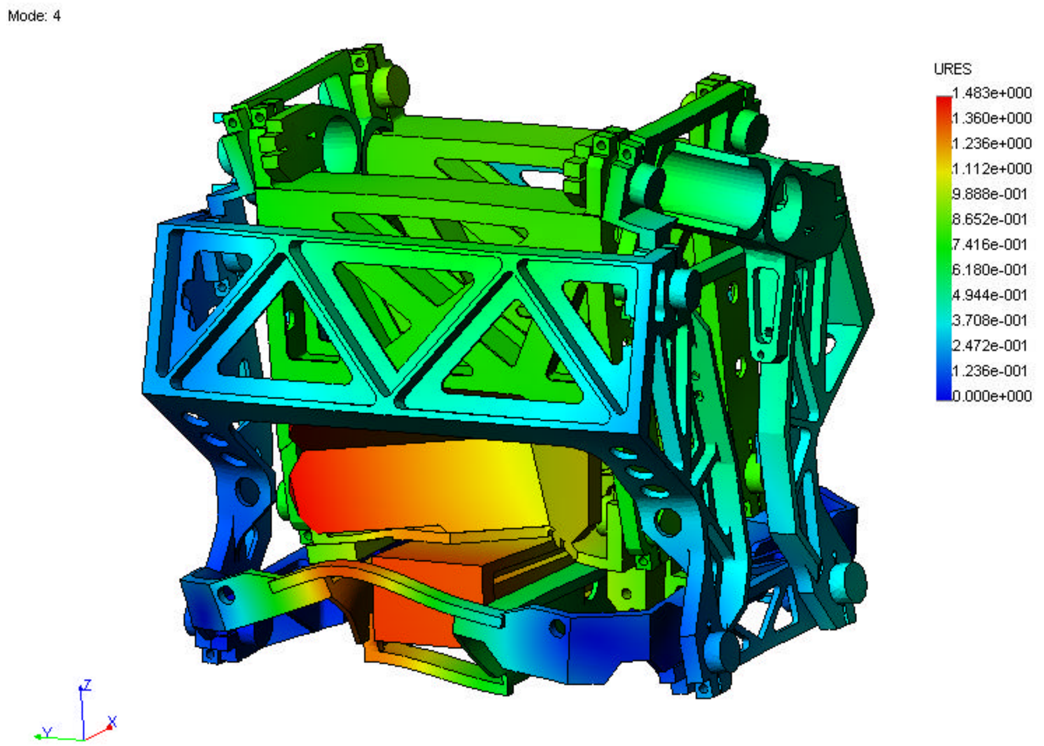
First Mode : 201,6 Hz – Longitudinal bending



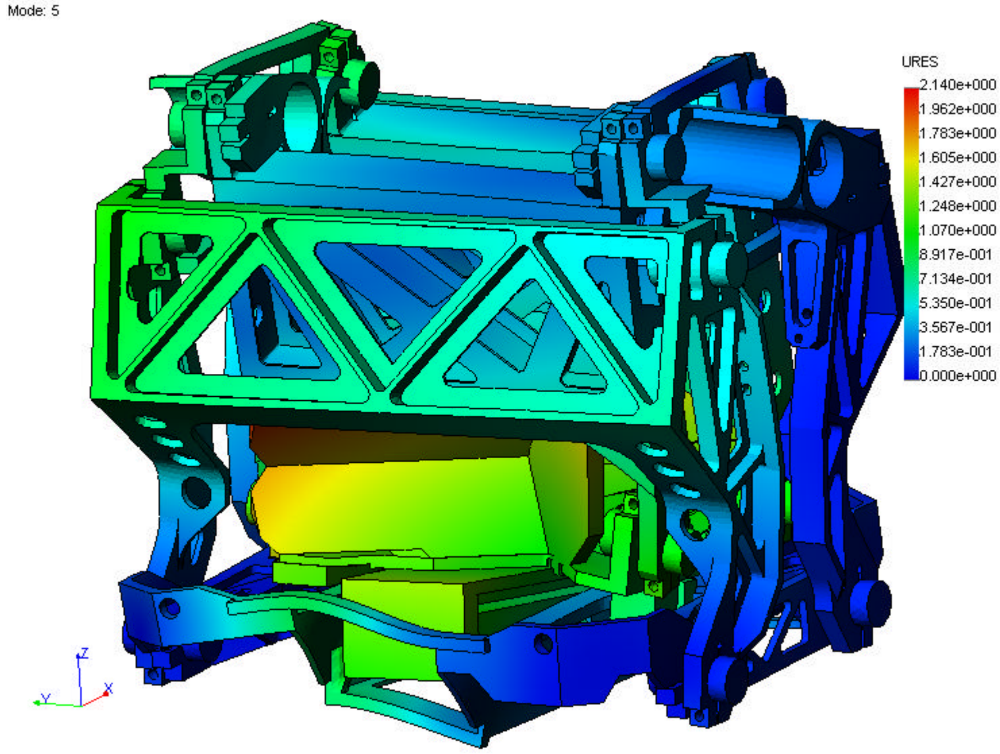
Second Mode : 243,8 Hz – Transversal bending



Third Mode : 296,2 Hz – Vertical torsion



Fourth Mode : 431,3 Hz – Base plate oscillation



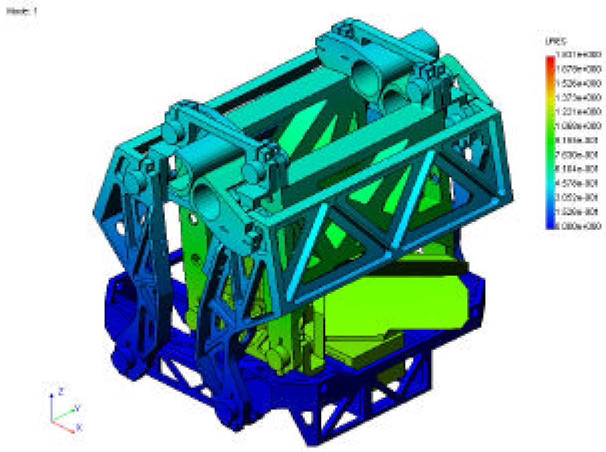
Fifth Mode : 499 Hz – Torsion + Bending

7. Unlatched Mechanism – Eigen Frequencies

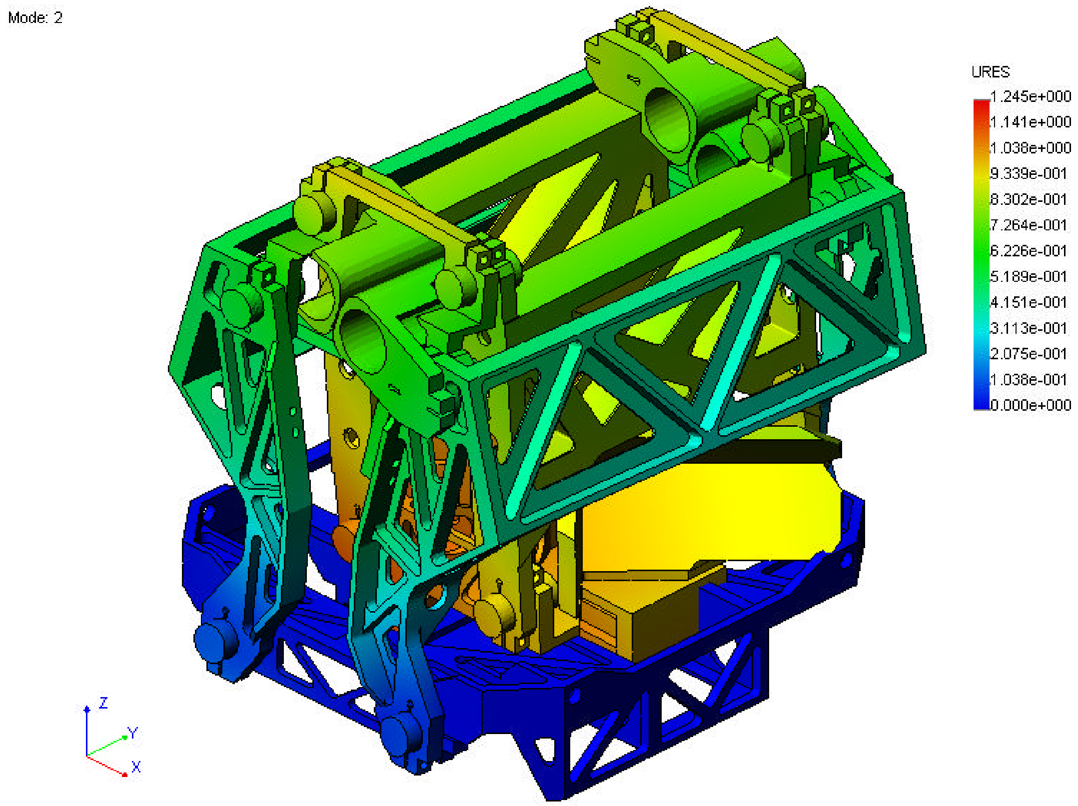
Calculations have been also performed with same model as before, but without plastic holds on the actuator (simulating launch latch).

Purpose of this analysis is to know :

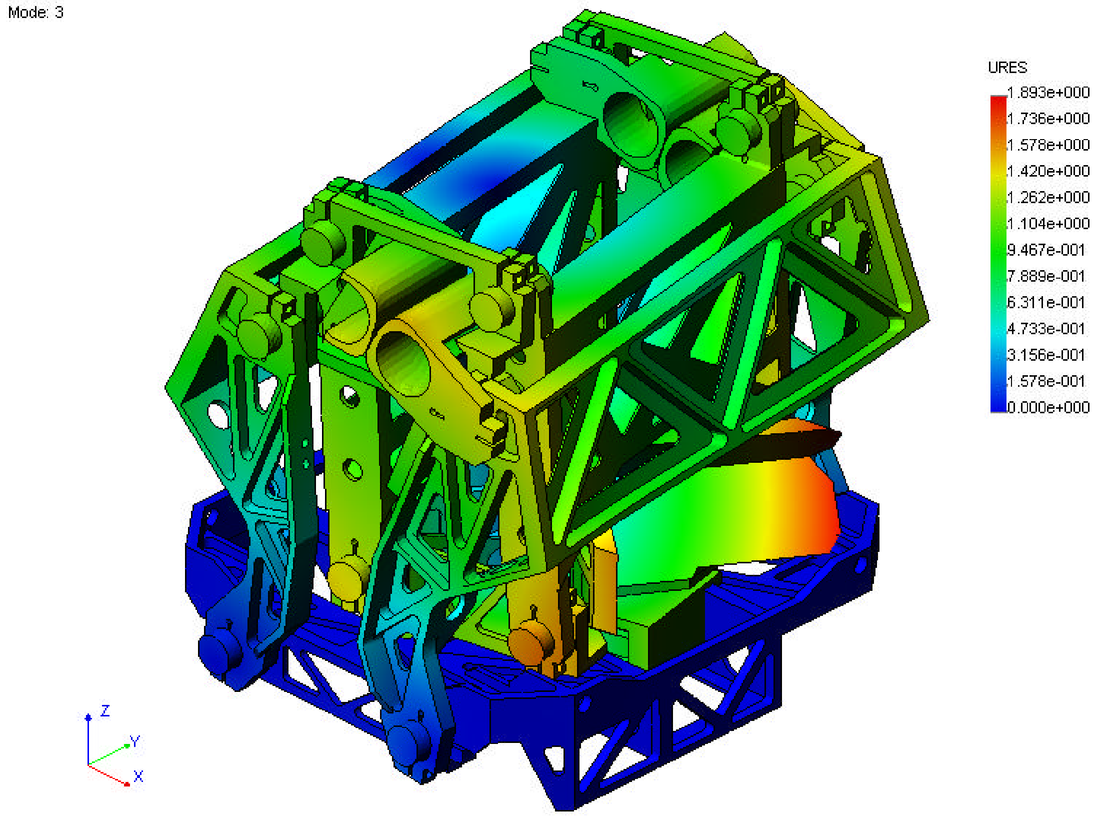
- what kind of spurious modes could affect PID control loop (at – 8mm absolute position of the carriage)
- what basic modes could be excited and nonlinearly limited by launch latch.



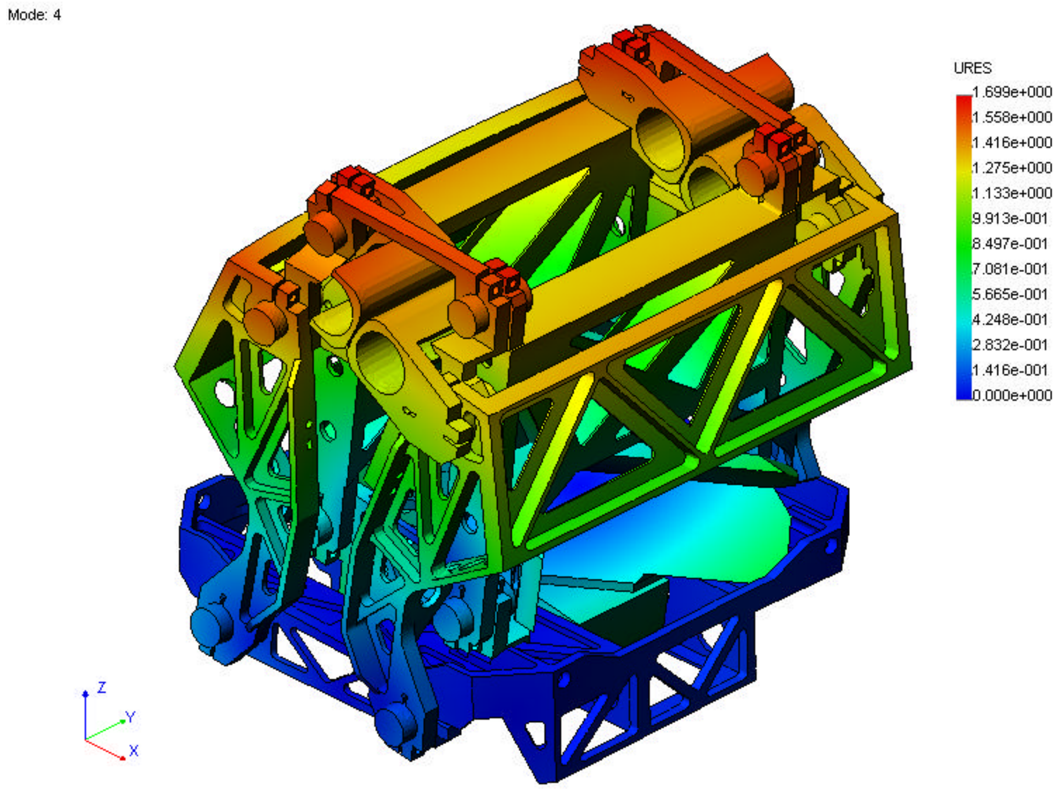
First Mode : 47,3Hz – « on axis » resonance ..
This Mode calculation is definitly very much affected by approximations of pivots and belts. Real value for X axis resonance is about 1 Hz.



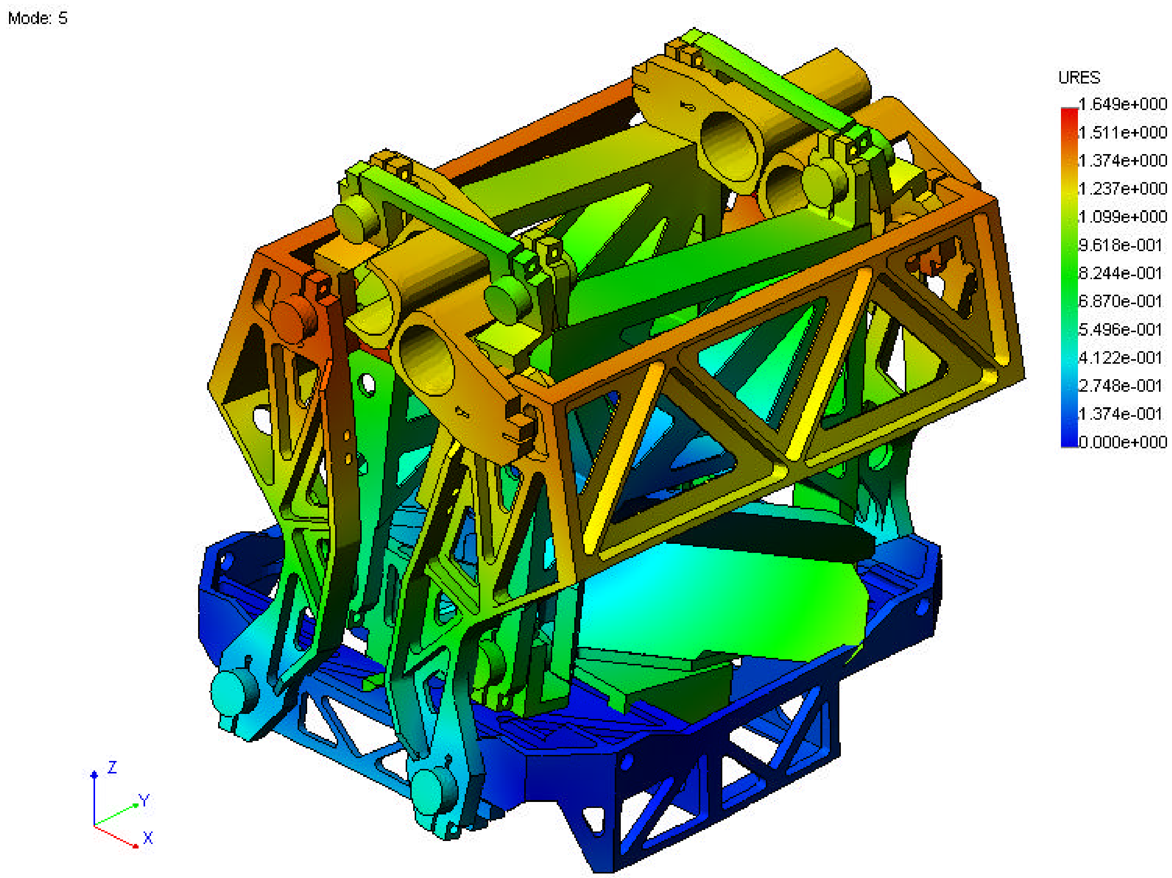
Second Mode : 94,8 Hz – Transversal deflection



Third Mode : 173,1 Hz – Vertical Torsion
This Mode would be very sensitive for control, as it leads to Actuator / Optical sensor misadjustment (movements of the actuator could be unseen by sensor)



Fourth Mode : 186,7 Hz -



Fifth Mode : 281 Hz -