Nano Hexapod - Obtained Design

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Contents

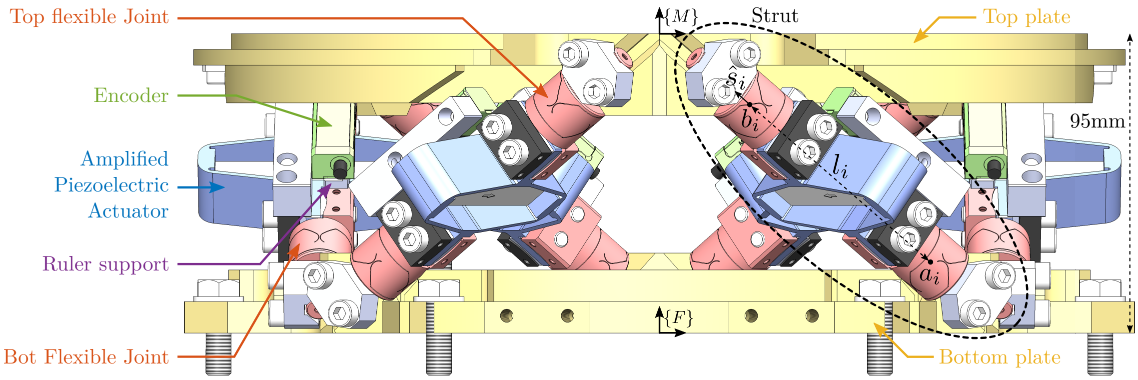


Figure 1: Obtained mechanical design of the Active platform, the "nano-hexapod"

Design goals:

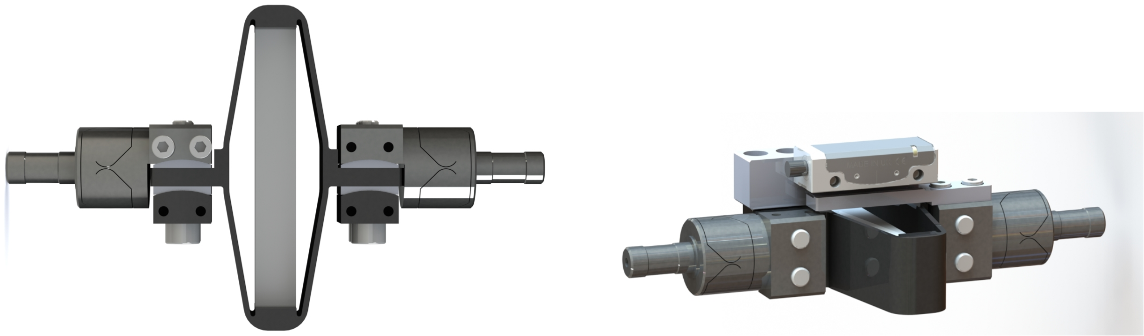
- Position `bi` and `si`
- Maximum height of 95mm
- As close as possible to "perfect" stewart platform: flexible modes at high frequency
- Easy mounting, easy change of strut in case of failure

Presentation of the obtained design:

- Fixation
- Section on: Complete strut
- Cable management
- Plates design
- FEM results
- Explain again the different specifications in terms of space, payload, etc..
- CAD view of the nano-hexapod
- Chosen geometry, materials, ease of mounting, cabling, . . .
- Validation on Simscape with accurate model?

1 Mechanical Design

1.1 Struts



(a) Before encoder integration

(b) With the mounted encoder

Figure 1.1: Design of the Nano-Hexapod struts. Before (a) and after (b) encoder integration.

Flexible joints

Flexible joints: X5CrNiCuNb16-4 (F16Ph)

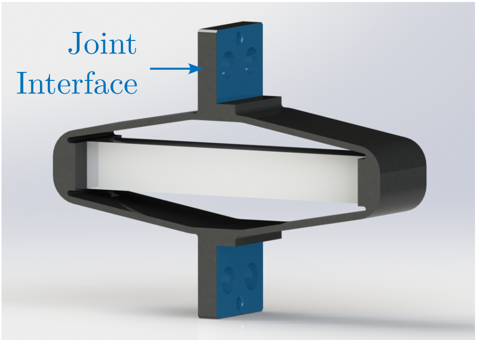
- high yield strength: specified ¿1GPa using heat treatment
- high fatigue resistance

Piezoelectric Amplified Actuators

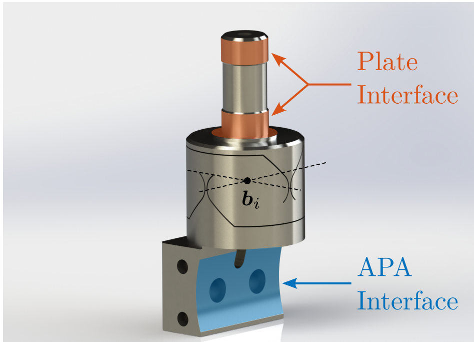
APA: modification for better mounting

Encoder support

All other parts are made of aluminum.



(a) Amplified Piezoelectric Actuator



(b) Flexible joint

Figure 1.2: Two main components of the struts: the amplified piezoelectric actuator (a) and the flexible joint (b).

1.2 Plates

Plates: X30Cr13

- high hardness to not deform
- Maximize frequency of flexible modes (show FEM)
- Good tolerances for interfaces with flexible joints Positioning of `bi` and orientation `si`

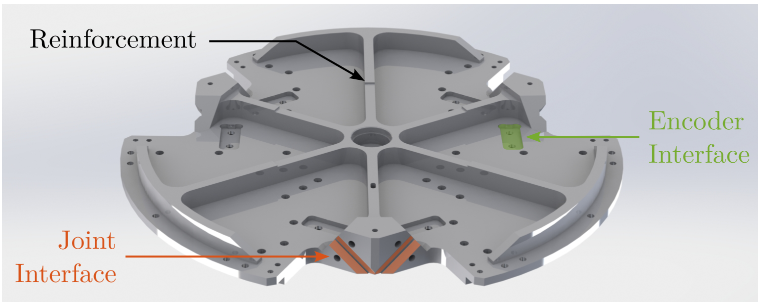
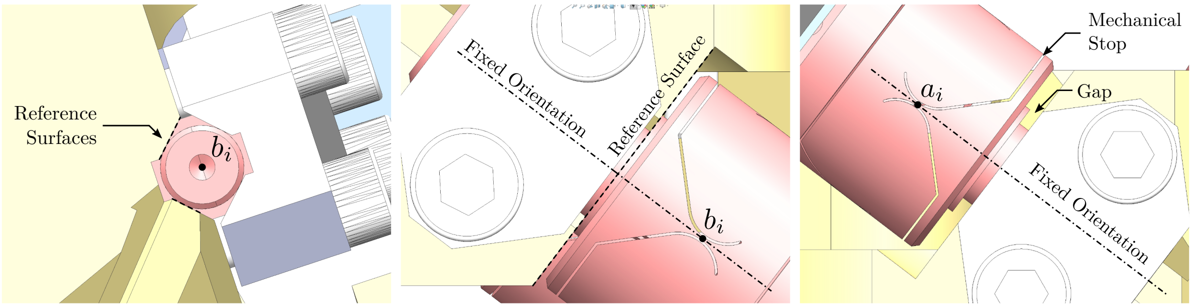


Figure 1.3: The mechanical design for the top platform incorporates precisely positioned V-grooves for the joint interfaces (displayed in red). The purpose of the encoder interface (shown in green) is detailed later.

The cylindrical component is located (or constrained) within the V-groove via two distinct line contacts.

1.3 Finite Element Analysis

- FEM of complete system
- Show modes of the struts



(a) Flexible Joint Clamping **(b)** Top positioning **(c)** Bottom Positioning

Figure 1.4: Fixation of the flexible points to the nano-hexapod plates. Both top and bottom flexible joints are clamped to the plates as shown in (a). While the top flexible joint is in contact with the top plate for precise positioning of its center of rotation (c), the bottom joint is just oriented (b).

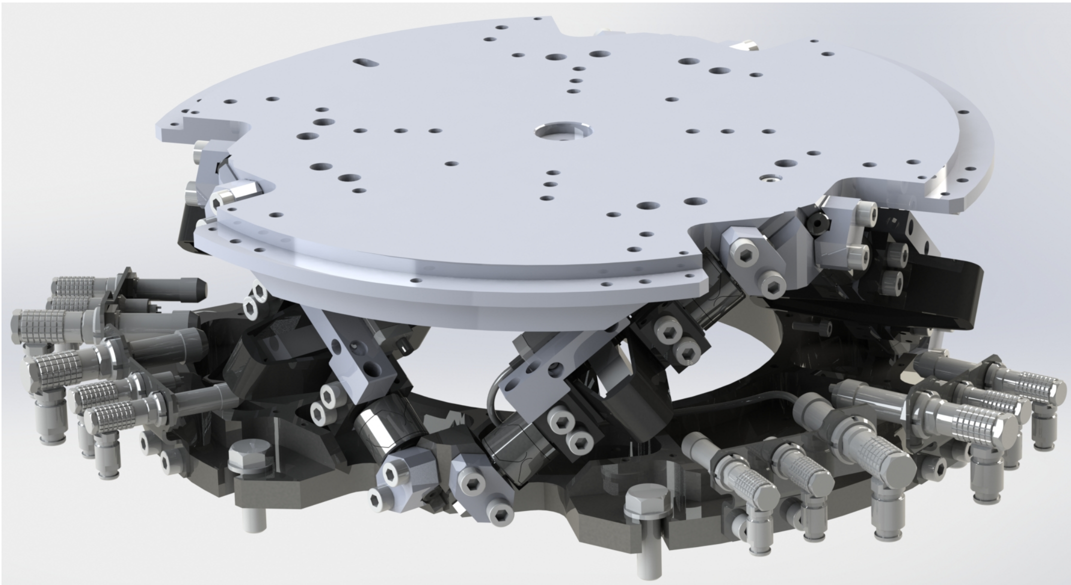
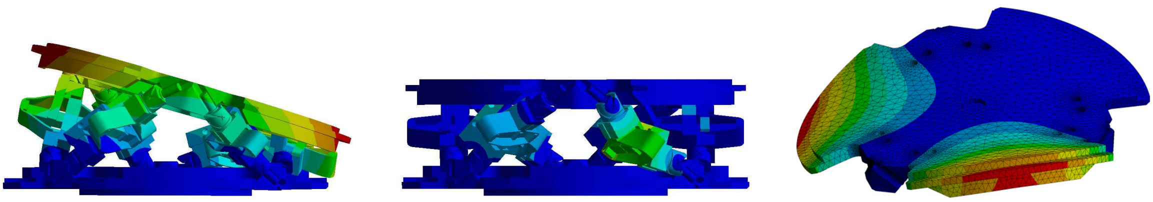


Figure 1.5: Obtained Nano-Hexapod design

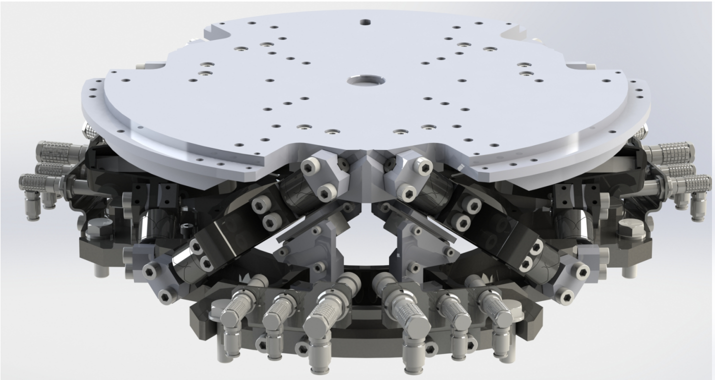


(a) Suspension modes **(b)** Strut - Local modes **(c)** Top plate modes

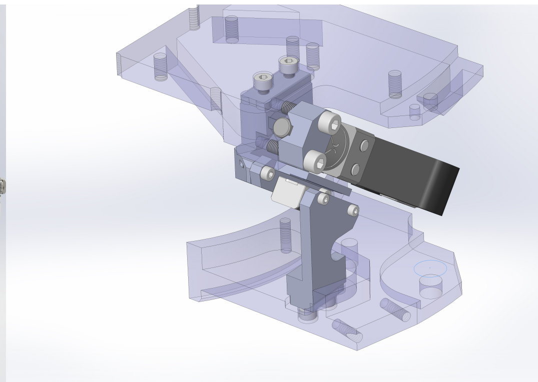
Figure 1.6: Measurement of strut flexible modes. First six modes are "suspension" modes in which the top plate behaves as a rigid body (a). Then modes of the struts have natural frequencies from 205 Hz to 420 Hz (b). Finally, the first flexible mode of the top plate is at 650 Hz (c)

1.4 Obtained Design

- Alternative encoder position: on the plates
- Support made of aluminum



(a) Nano-Hexapod with encoders fixed to the plates



(b) Zoom on encoder fixation

Figure 1.7: Alternative way of using the encoders: they are fixed directly to the plates.

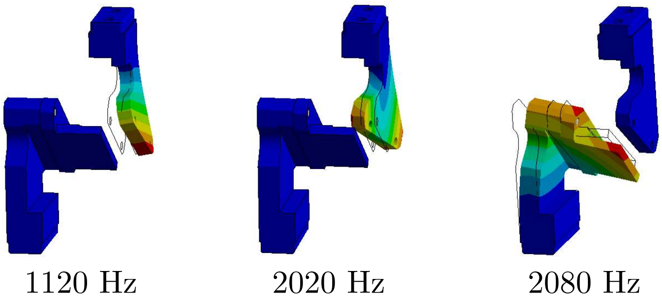


Figure 1.8: Finite Element Analysis of the encoder supports. Encoder inertia was taken into account.

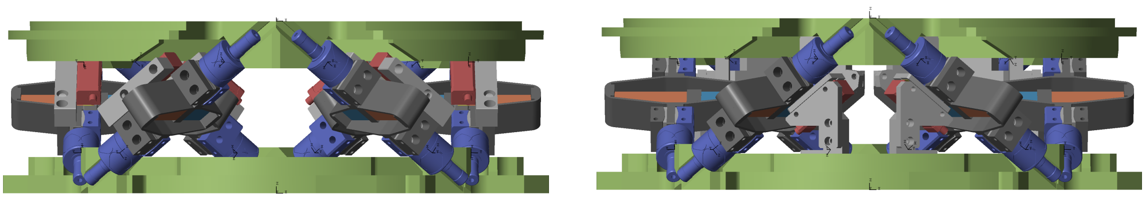
2 Multi-Body Model

Multi body Model:

- Complete model: two plates, 6 joints, 6 actuators, 6 encoders
- Joint Model
- APA Model
- Encoder model
- Say that obtained dynamics was considered good + possible to perform simulations of tomography experiments with same performance as during the conceptual design

Two configurations:

- Encoders fixed to the struts
- Encoders fixed to the plates



(a) Encoders fixed to the struts

(b) Encoders fixed to the plates

Figure 2.1: 3D representation of the multi-body model. There are two configurations: encoders fixed to the struts (a) and encoders fixed to the plates (b).

2.1 Flexible Joints

2.2 Amplified Piezoelectric Actuators

2.3 Encoders

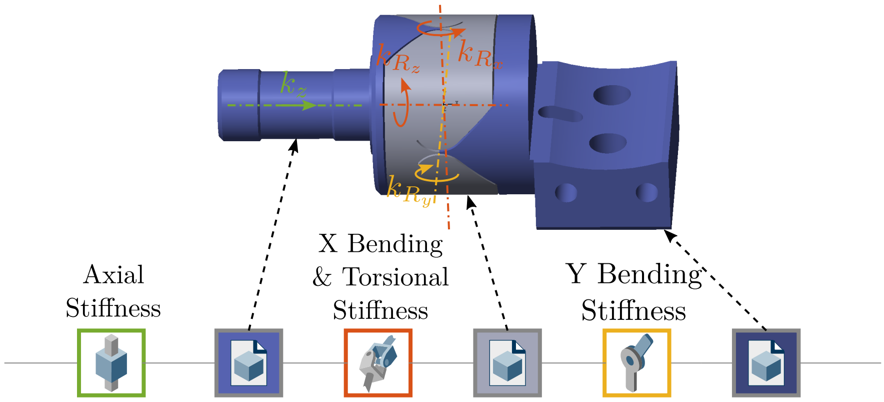


Figure 2.2: Multi-Body (using the Simscape software) model of the flexible joints. A 4-DoFs model is shown.

(a) Aligned encoder and ruler

(b) Rotation of the encoder head

Figure 2.3: Representation of the encoder model in the multi-body model. Measurement d_i corresponds to the x position of the encoder frame $\{E\}$ expresssed in the ruller frame $\{R\}$ (a). A rotation of the encoder therefore induces a measured displacement (b).

3 Conclusion