FRAME

Objective

- ⇨ Structure the car and ensure the position and the sustainability of other systems
- ⇨ Ensure the pilot security

Conception steps:

Step 1: The rules imposed few extremal dimensions as the size of the cockpit, the front of the frame and also the position of tubes on the side impact.

Step 2: Suspension preference-based conception.

Step 3: Make the integration of the engine easier thanks to removable bracings.

Step 4: Improve the pilot position making it more comfortable. Minimization of the front hoop in order to improve the pilot visibility.

Important values

- Stiffness
  - Target: 1000-1500 Nm/deg
  - Simulation: 1114 Nm/deg
  - Measure: 1205 Nm/deg
- Weight with paint and equipment
  - Target: 39-42 kg
  - Simulation: 40.6 kg
  - Measure: 41 kg
- Steel: 25CD4S (AISI4130)
  - Yield strength: 7.10^8 N/m²

Simulation

Hypothesis

- Elastic behaviour
- Small displacement
- Welds infinitely stiff
- No dynamic phenomenon
- Beam model

Results

NB: Except for torsion , all load cases come from MécaMaster

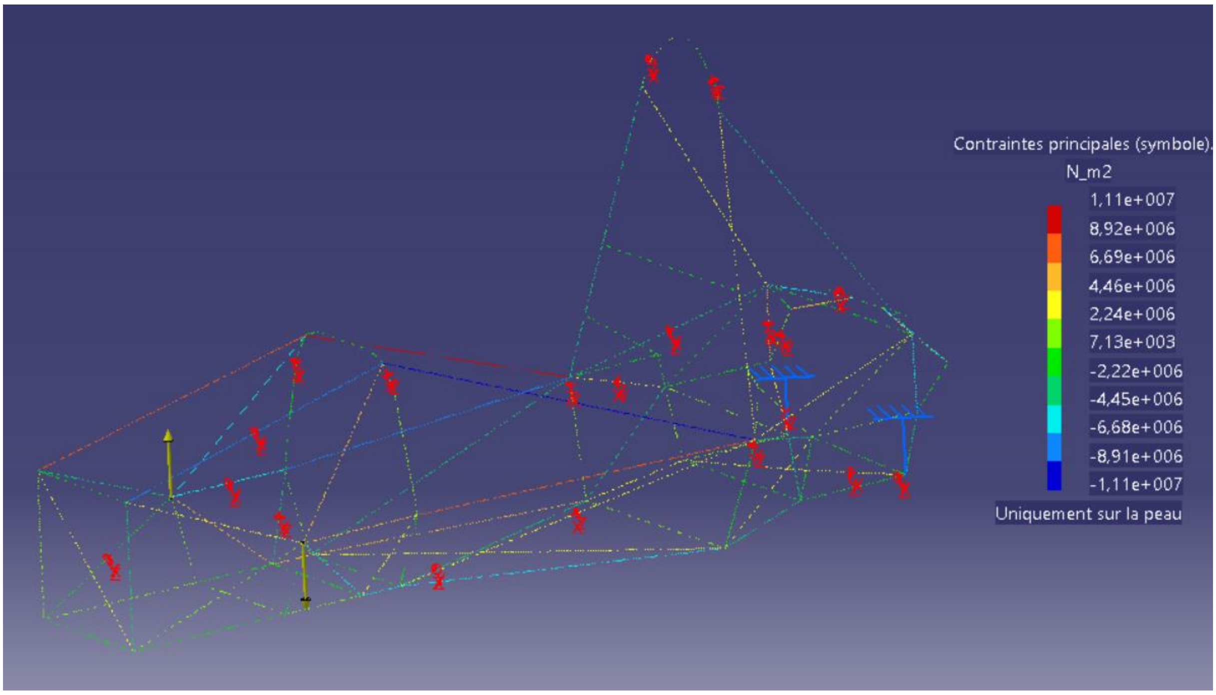

Figure 1: Torsion

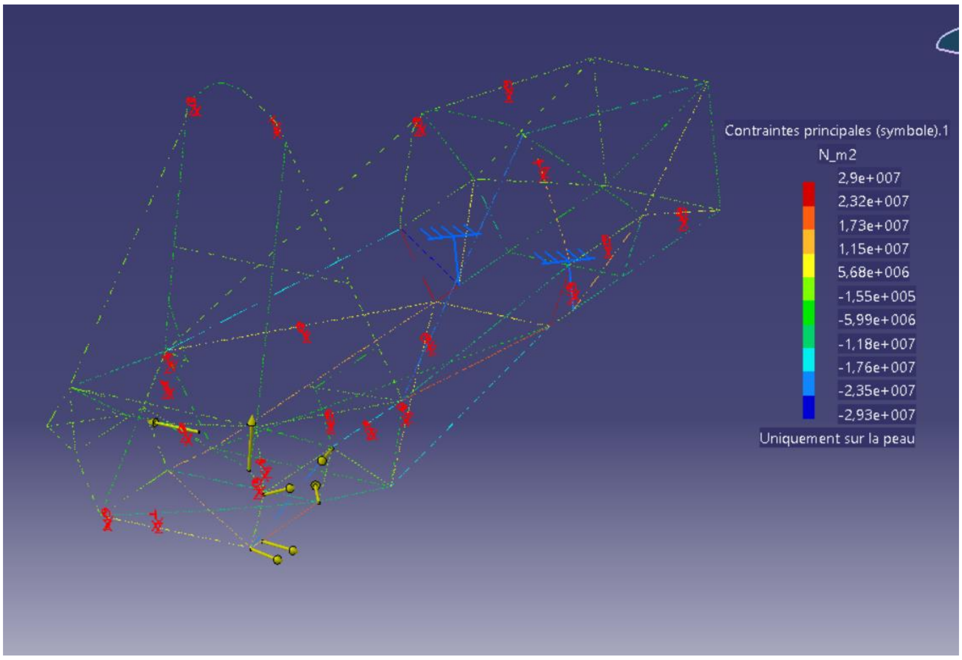

Figure 2a: Acceleration 0.77g

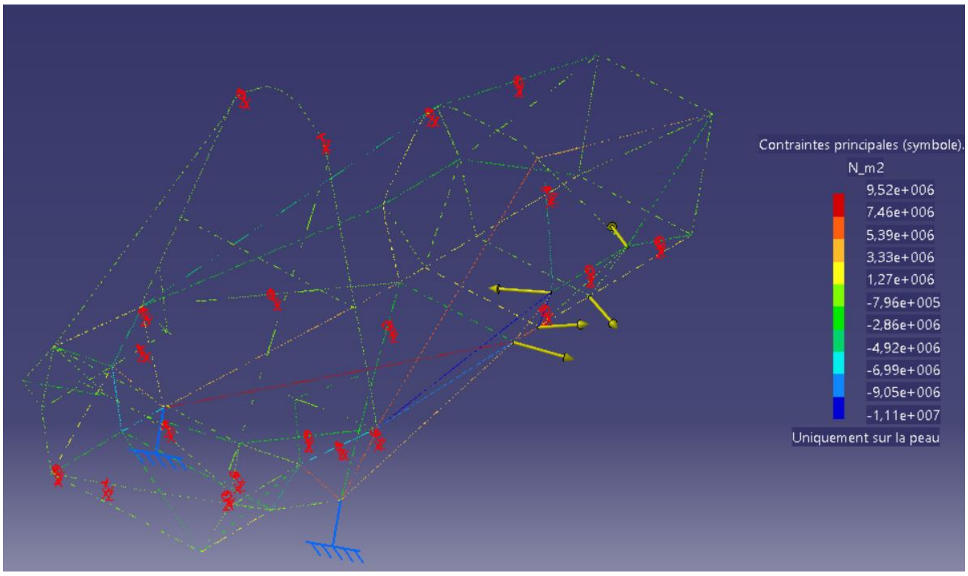

Figure 2b: Acceleration 0.77g

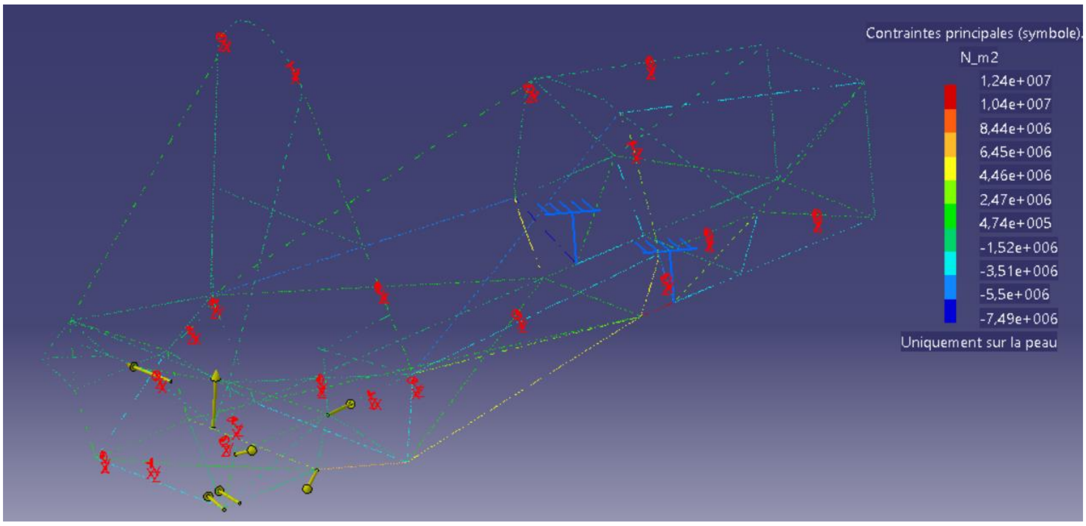

Figure 3a: Braking 2g

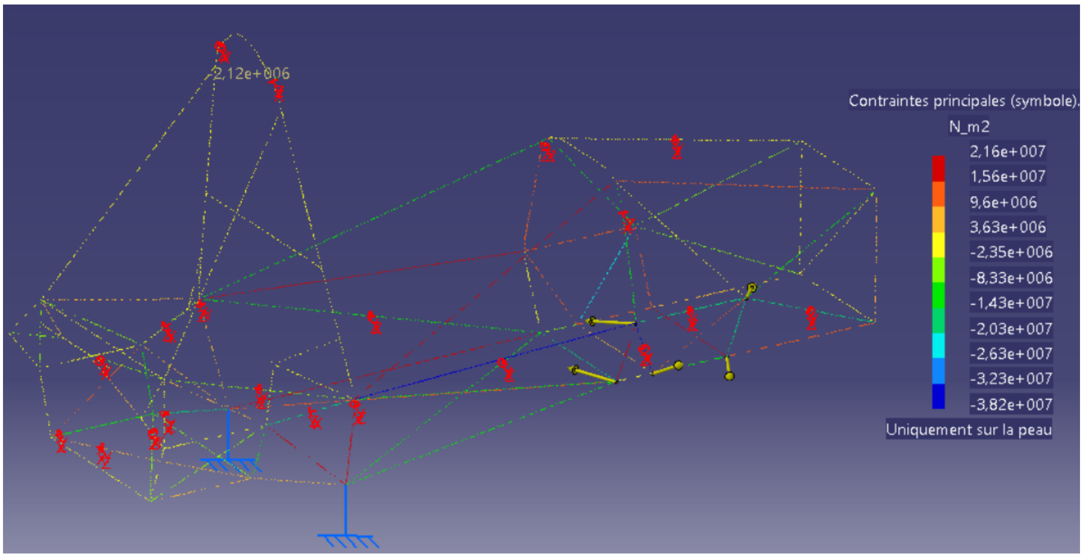

Figure 3b: Braking 2g

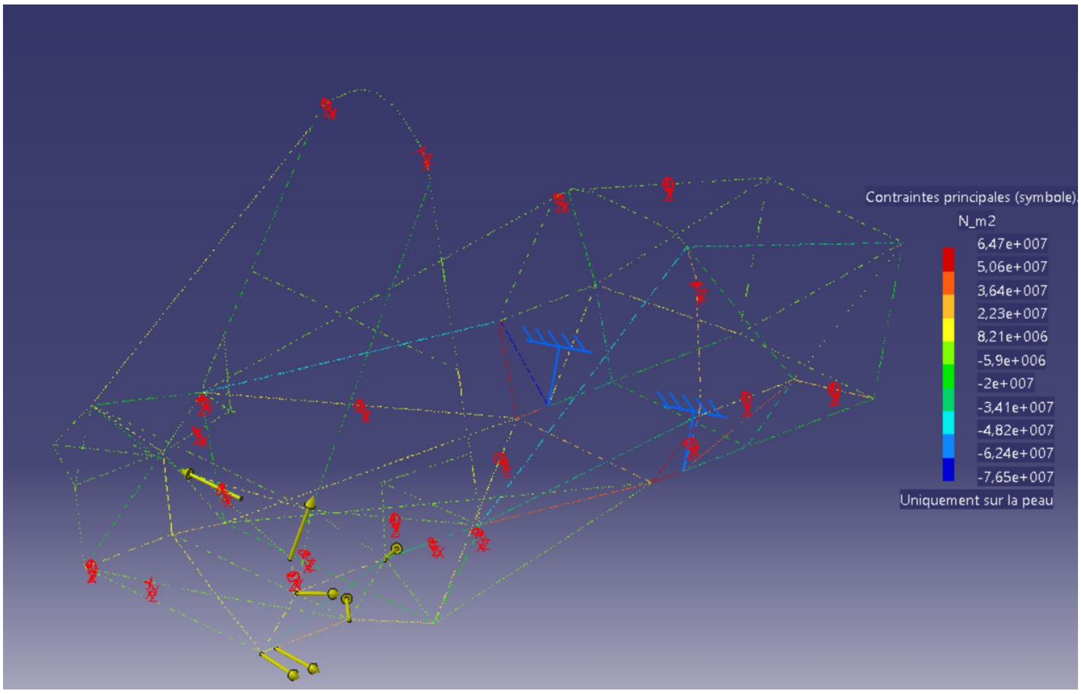

Figure 4a: Bump 3g

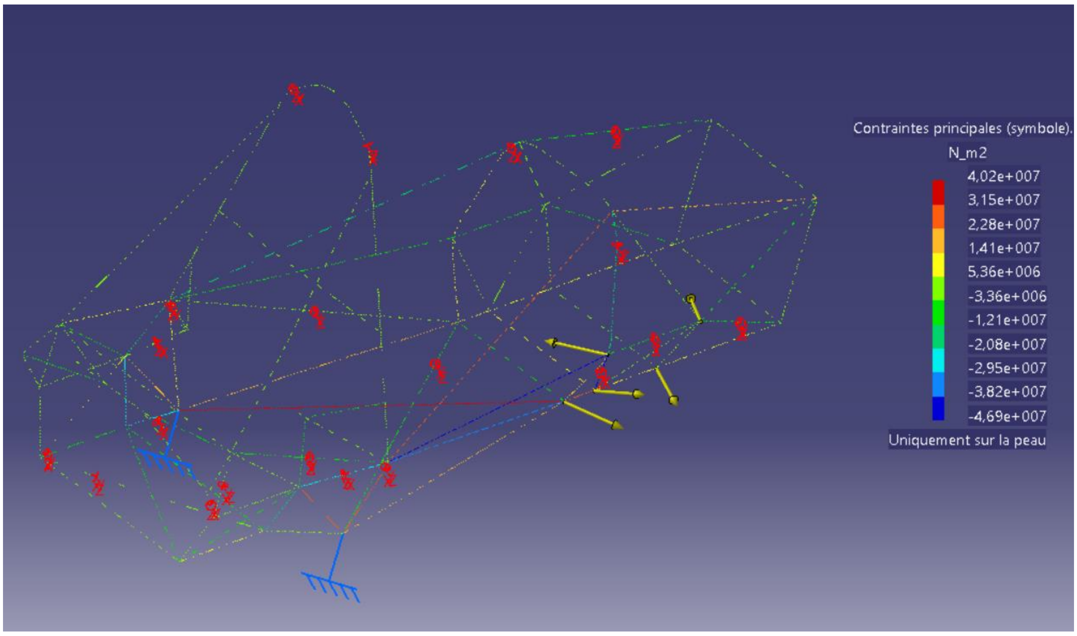

Figure 4b: Bump 3g

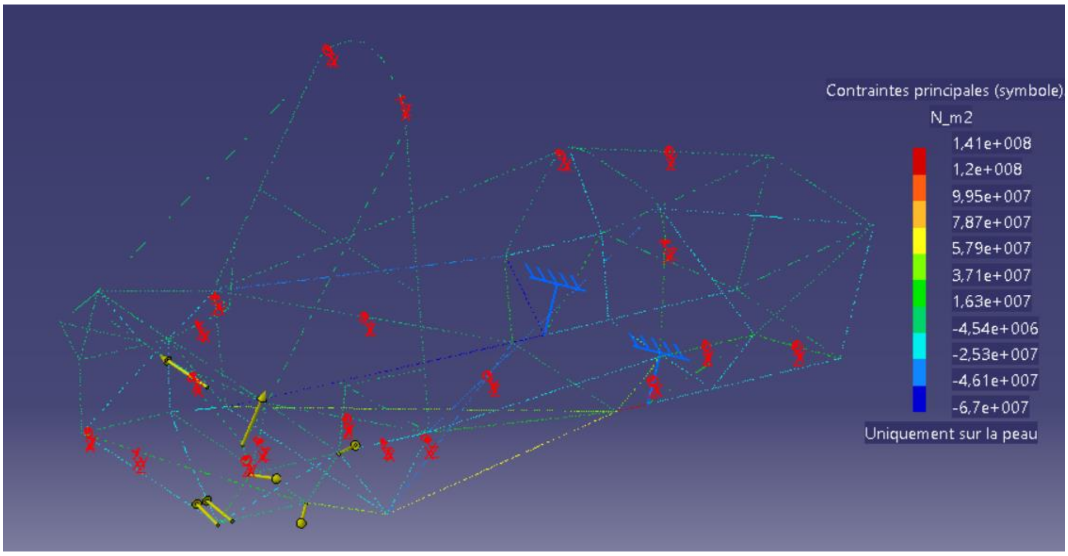

Figure 5a: Left turn 2g

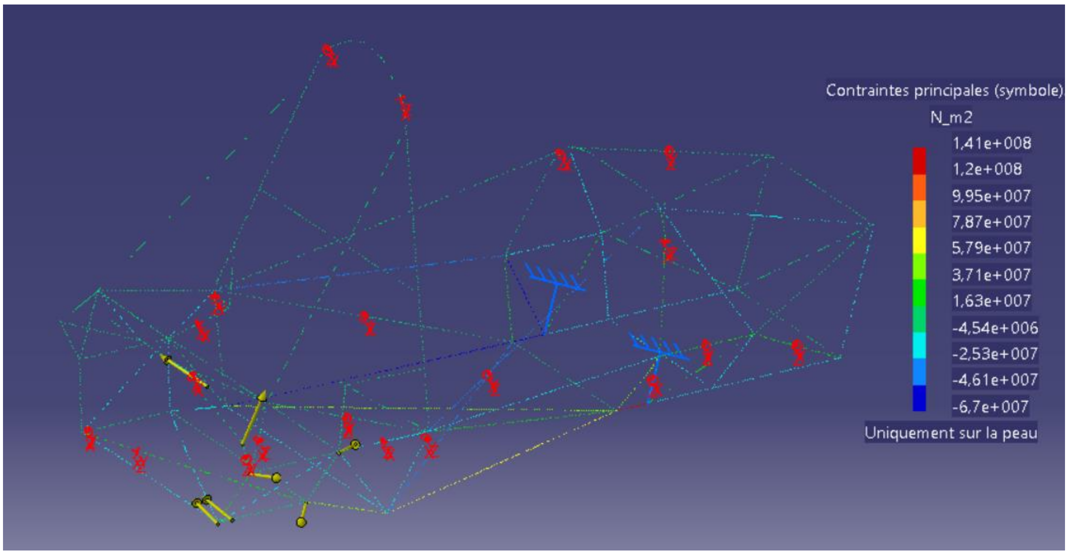

Figure 5b: Left turn 2g

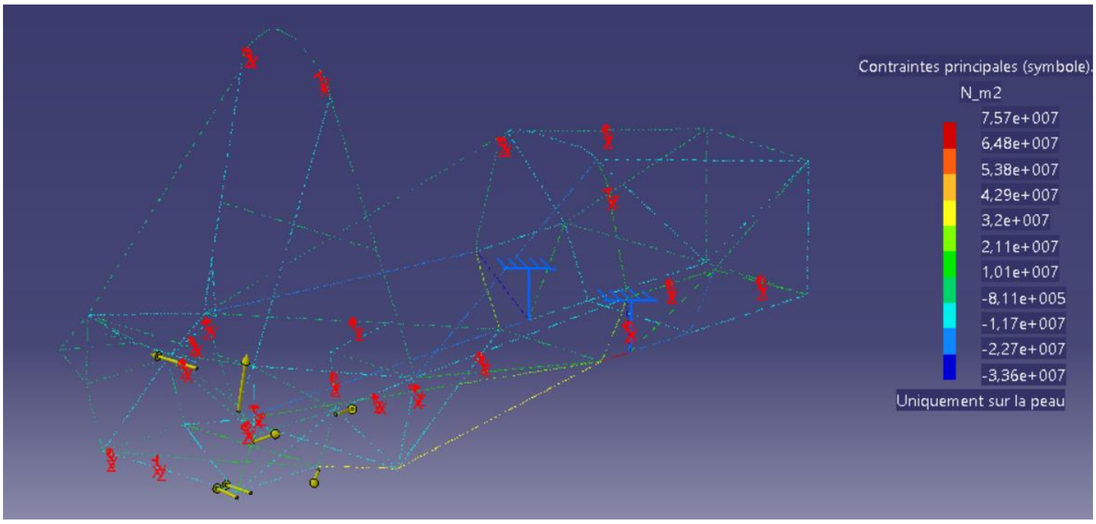

Figure 6a: Left turn 1g + braking 1g

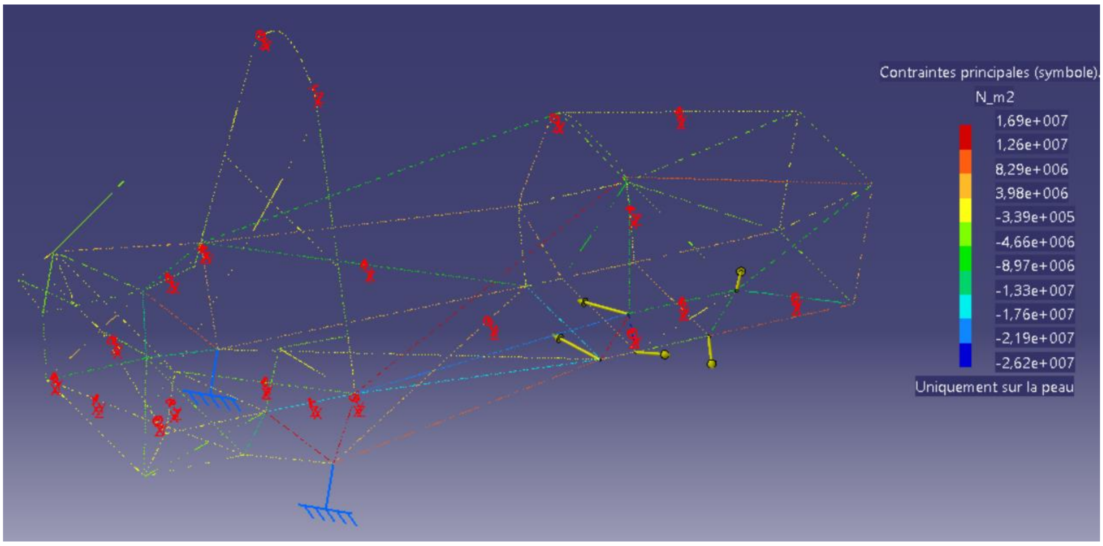

Figure 6b: Left turn 1g + braking 1g

Stiffness measure experiment

Figure 7: Stiffness measurement on the frame

Measure performed in two times:

- Apply a torque to the front and the cockpit of the frame, blocking the back
- Apply a torque at the back, blocking the front

The difference between the simulated and the measured values may come from the boundaries conditions that are not exactly the same.

Equipment positioning

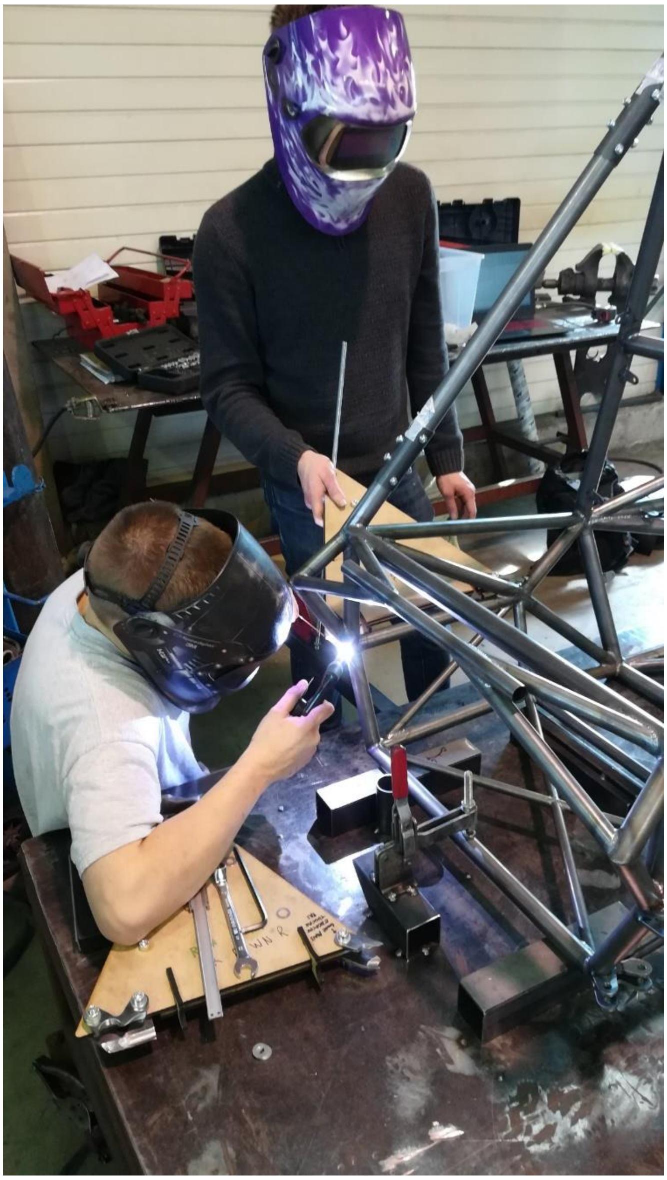

Figure 8: Use of templates to precisely positioned equipment during welding

Appendix

Stiffness model (coefficient α)

Frame: 3 series torsion springs

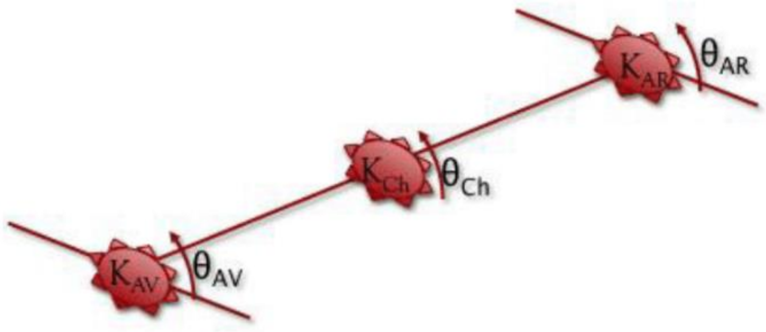

Figure 9: Definition of the model

Where K=stiffness and Θ=angle. We also define K_T and θ_T respectively the stiffness and the angle of the car.

In order to simplify the equations, we suppose $K_{AV} = K_{AR};\ \alpha . K_{AV} = K_T\ and\ \theta_{AV} = \theta_{AR}$. It gives us the following equations:

$$\begin{aligned} K_T &= \left(\frac{1}{K_{AV}} + \frac{1}{K_{Ch}} + \frac{1}{K_{AR}}\right)^{-1} \\ \theta_T &= \theta_{AV} + \theta_{Ch} + \theta_{AR} \end{aligned} \quad \Leftrightarrow \quad \begin{aligned} K_T &= \frac{\alpha}{1+2\alpha} K_{AV} \\ \theta_T &= 2\theta_{AV} + \theta_{Ch} \end{aligned}$$

$$E_p = \frac{1}{2} K_T \theta_T^2 = \frac{1}{2} K_{AV} \theta_{AV}^2 + \frac{1}{2} K_{Ch} \theta_{Ch}^2 + \frac{1}{2} K_{AR} \theta_{AR}^2$$

Finally,

$$\frac{\theta_{Ch}}{\theta_T} = \frac{1}{1+2\alpha}$$

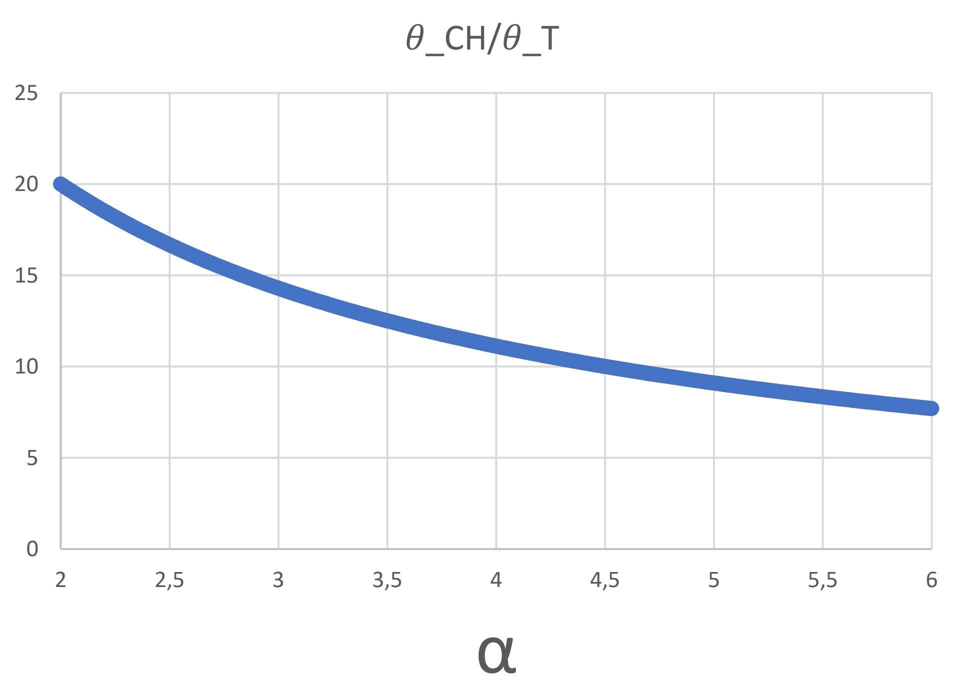

Figure 9: Coefficient of relative stiffness regarding suspension

If we want to keep θ_{CH}/θ_T between 10% and 15%, we have to take α between 3 and 5.

Pilot position

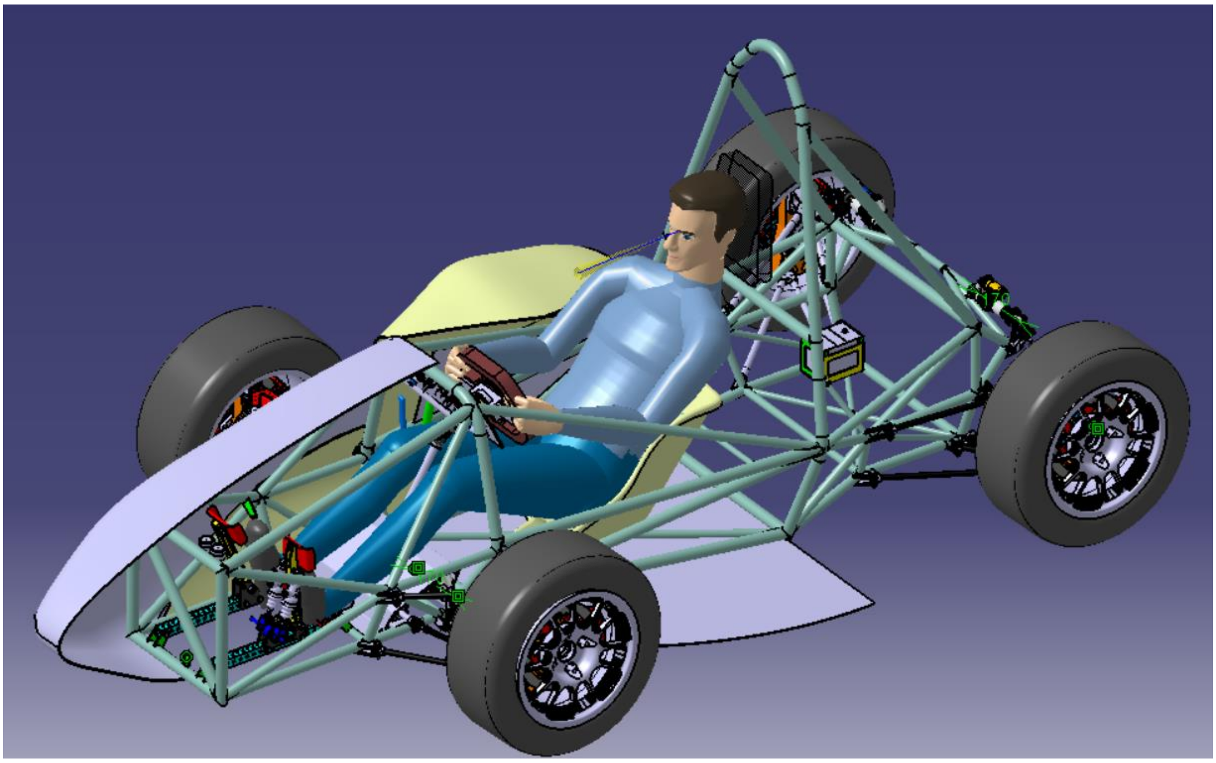
Figure 10: Human model in CAD model to help designing the chassis