# Finite-element simulations of aluminium components during collisions

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# Outline

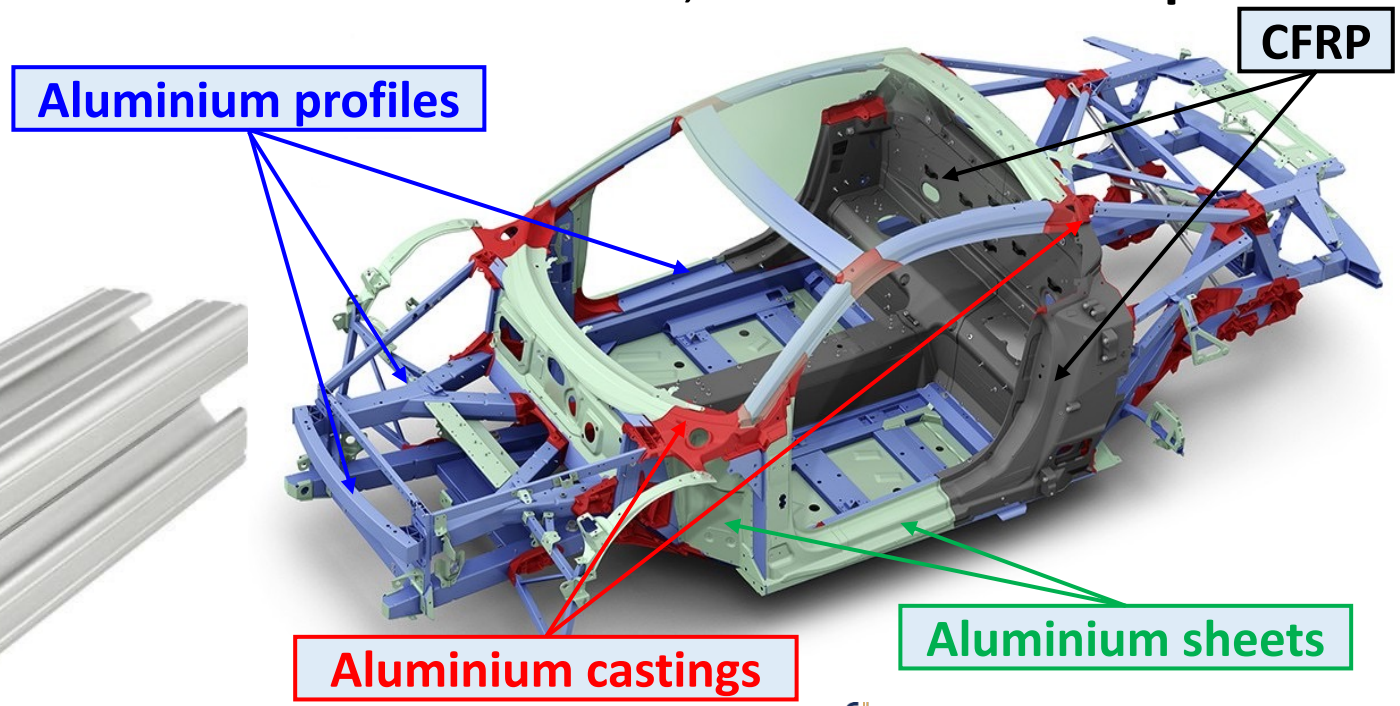
- 1. Introduction
- 2. On the effects of variations in chemical composition
- 3. On the effects of variations in plastic and failure anisotropy
- 4. Conclusions and future work

# 1.1. Motivation (favourable properties)

- Global tendency of **reducing energy consumption** and **$CO_2$ emissions**. **Major increase** in the use of aluminium in the automotive industry because of **many favourable properties. Results** also applicable to **other sectors**

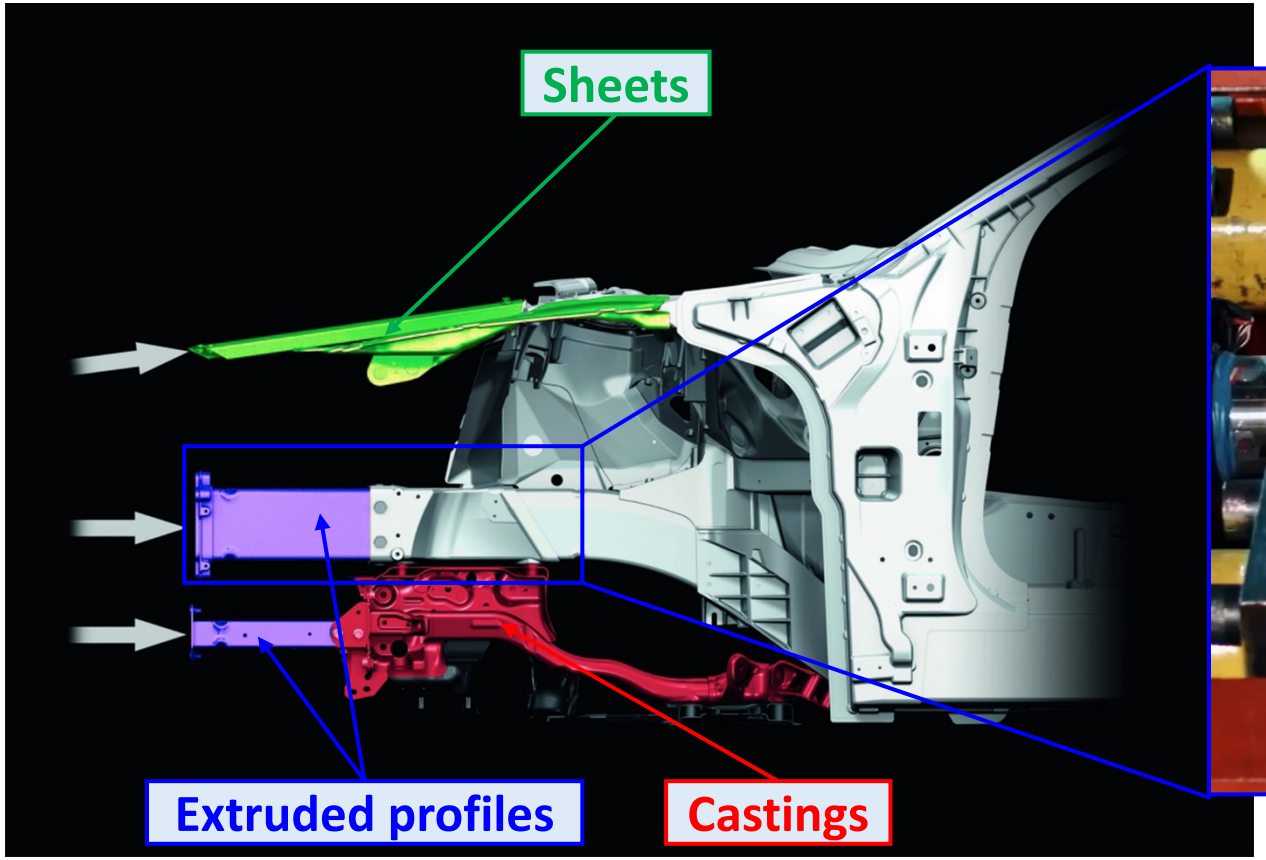
- Aluminium can be extruded with **complex cross sections**, **single** or **multi-chamber profiles.** Automotive structures in aluminium → **Rolled sheets**, **extrusion-based profiles** and **cast components**

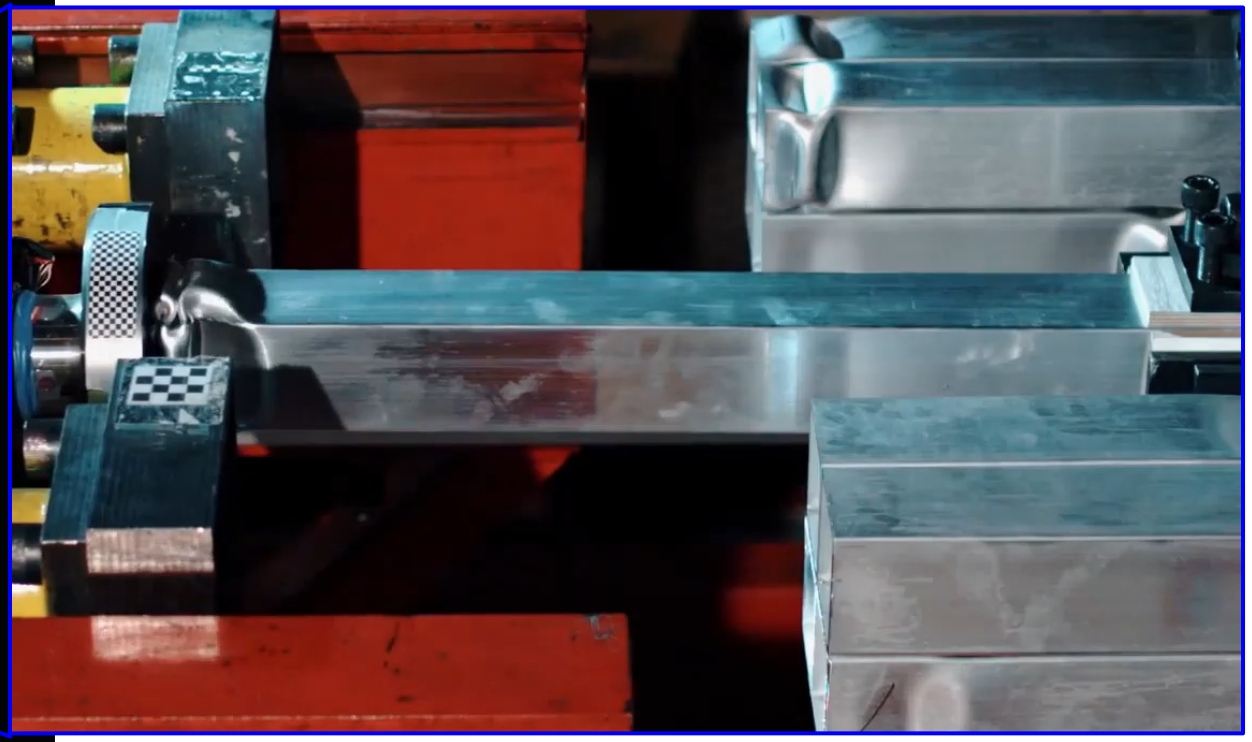
- **Energy-dissipating structures (BIW)**



# 1.1. Motivation (front-end impact)

- **Extruded longitudinal members** must absorb the **forces through load paths**



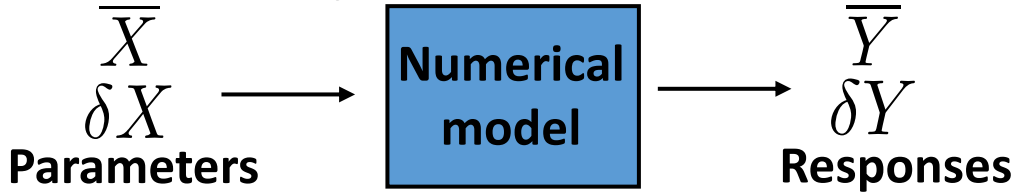



# 1.1. Motivation (robustness)

- **Variations** in **geometry/materials** → Variations in **structural behaviour** → **Non-robust design** of these structures

- **Robust behaviour** = **Good performance** regardless of any variations

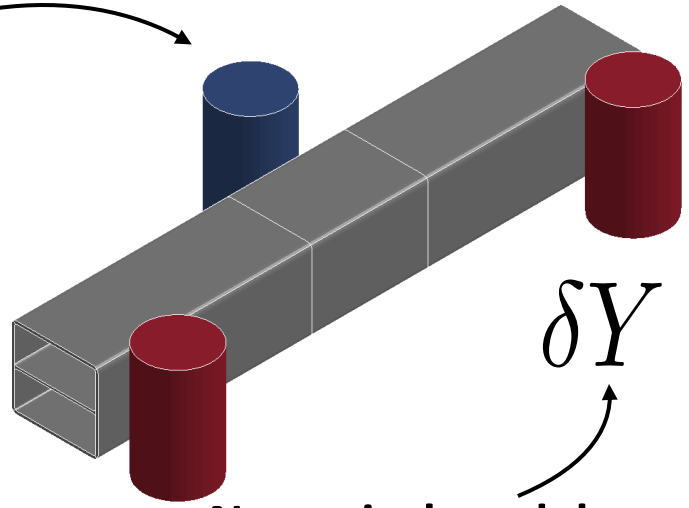
- Usage of **large-scale FE analyses** is needed




$\delta X = ?$

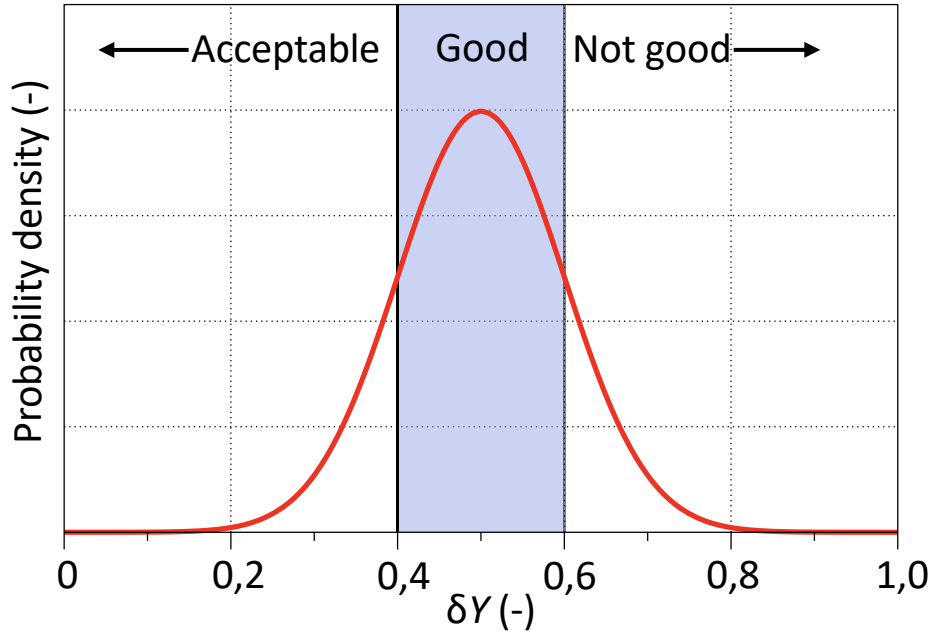
```
*MAT_258
$#     MID       RHO         E        NU    SIGMA0         A       KSI      rmap
         1  2.71e-09   70000.0      0.30    328.73       8.0       0.0       0.0
$#  THETA1        Q1    THETA2        Q2    THETA3        Q3
    725.90     10.55   1133.25     91.79       0.0       0.0       0.0       0.0
$#      CS     PDOTS
       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
$#   DCRIT       WCB       WCL       WCS         C       PHI     GAMMA
       1.0    191.01     48.08     92.67    0.9029       1.0       1.0
*END
```

**Material models**



$\delta Y = ?$

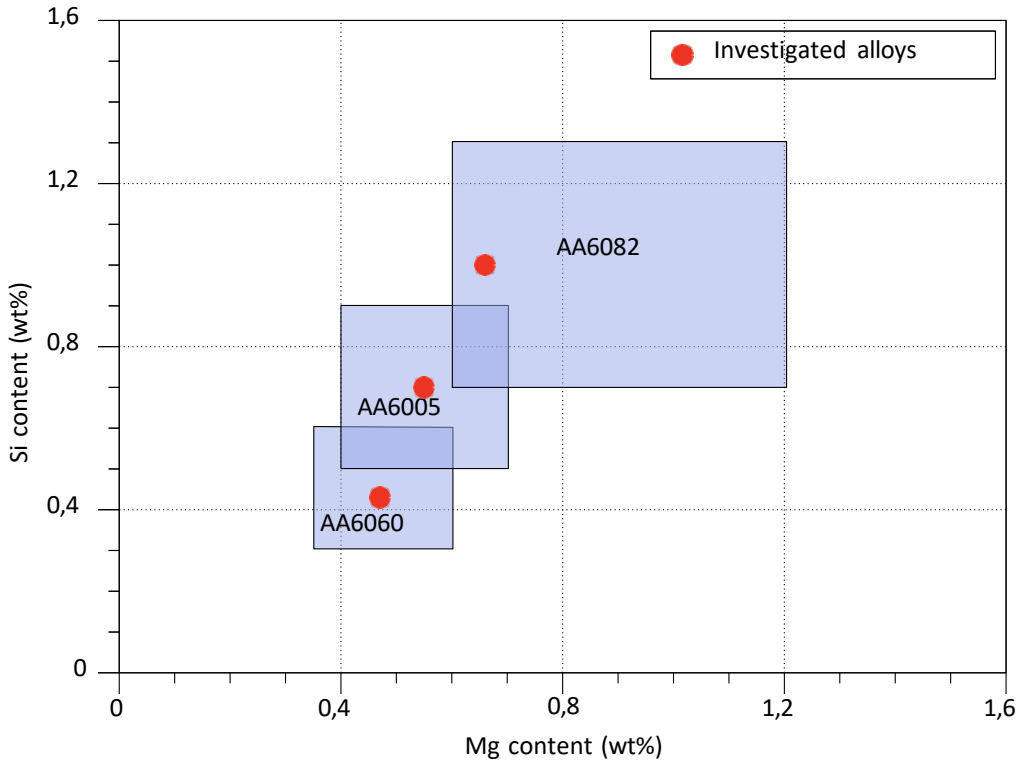
**Numerical model**



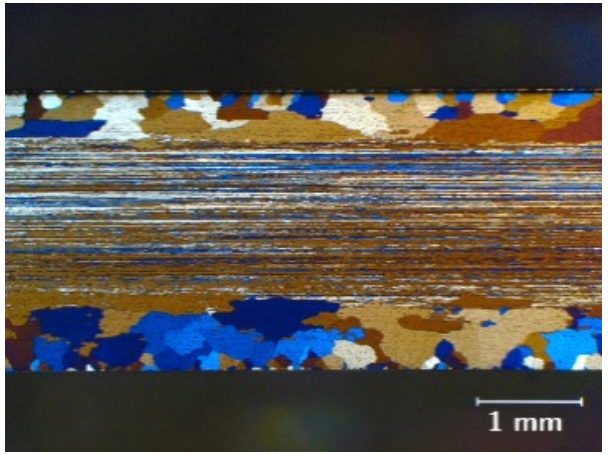
# 1.1. Motivation (challenges in large-scale FE analyses)

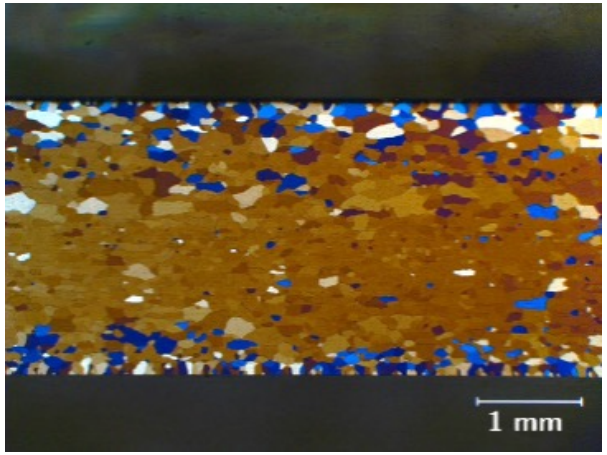
- Chemical composition within some **tolerances → Variations in chemical content**
- Extrusion **manufacturing** process → **Plastic and failure anisotropy**

**Idealized chemical composition**




**Anisotropy**



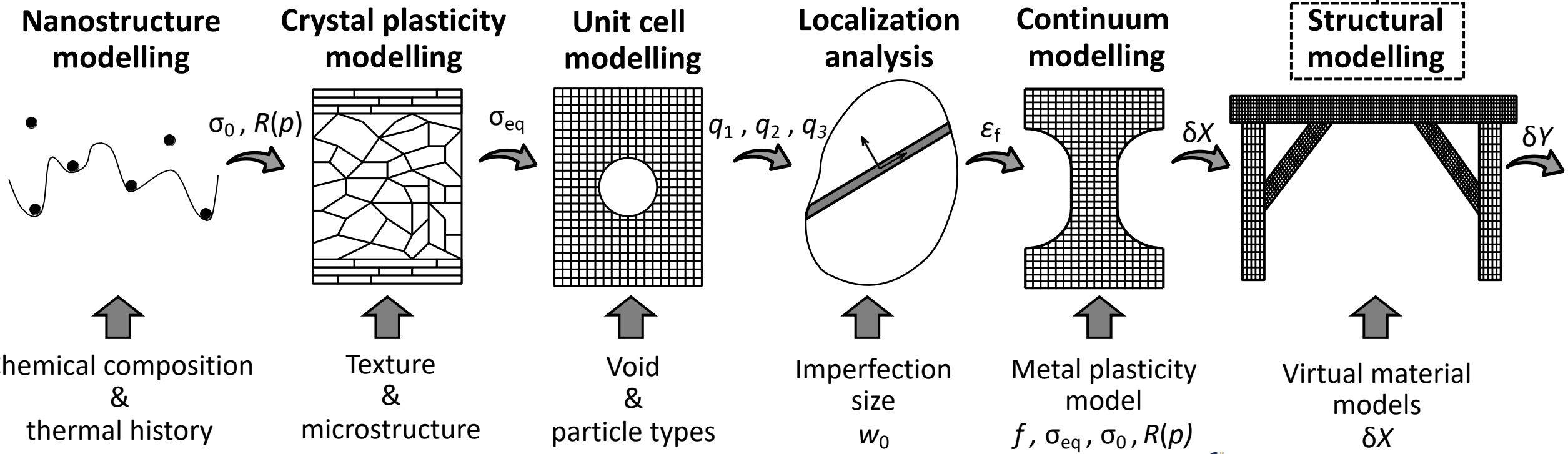



# 1.2. Research strategy (interdisciplinary approach)

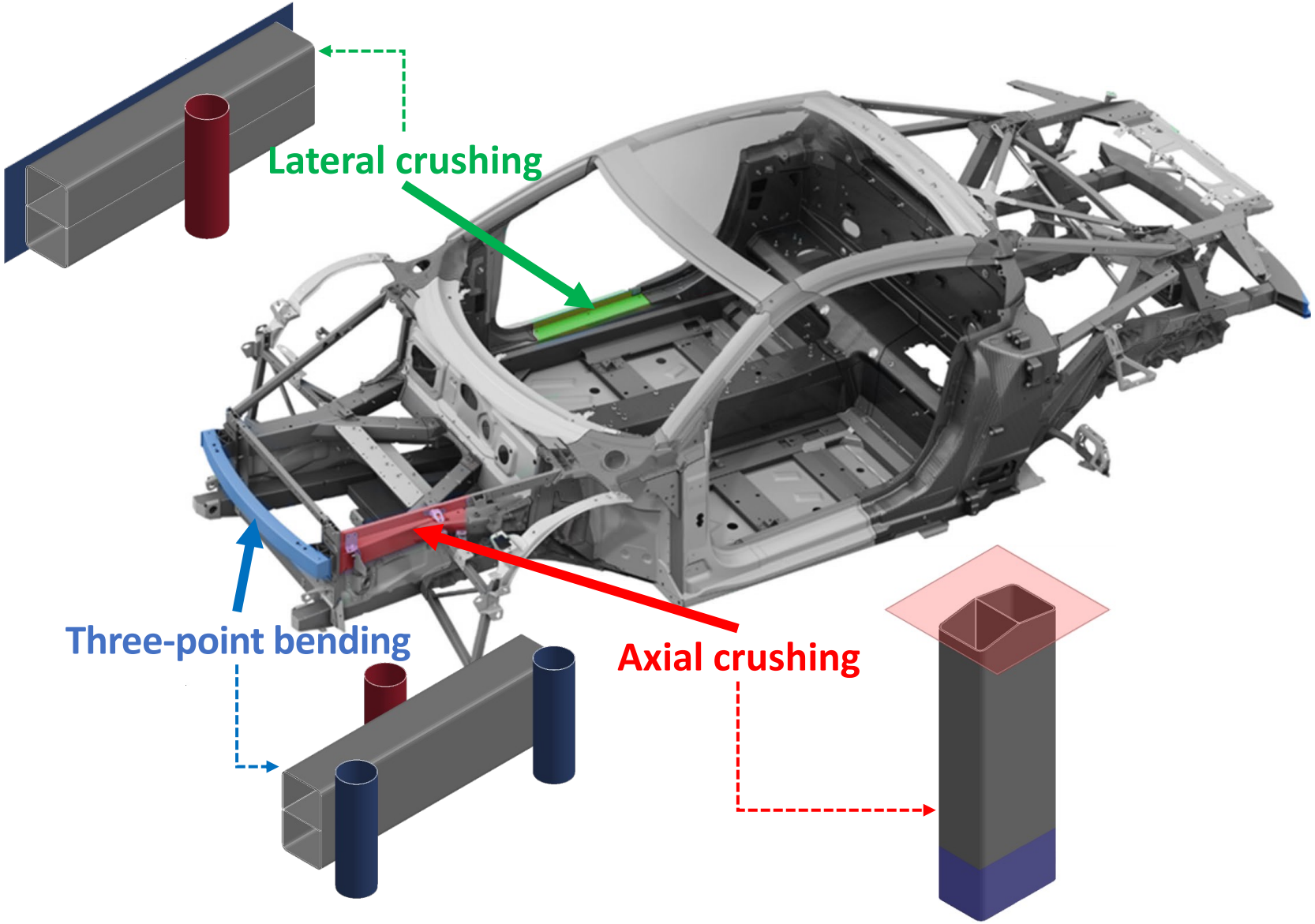
- **Overall strategy → Refined numerical models** that are assumed to be **correct** in order to later **calibrate simplified numerical models** that can be used in **large-scale analyses of structural components**

- **Virtual laboratory (VL):**

Variations:
- Chemical Composition
- Plastic Anisotropy
- Anisotropic Fracture

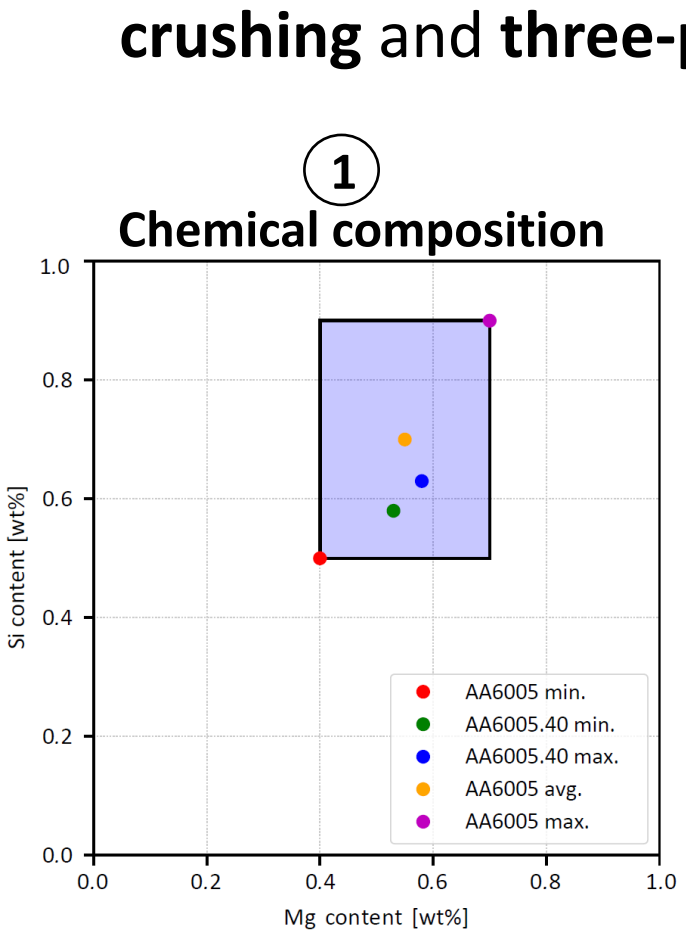


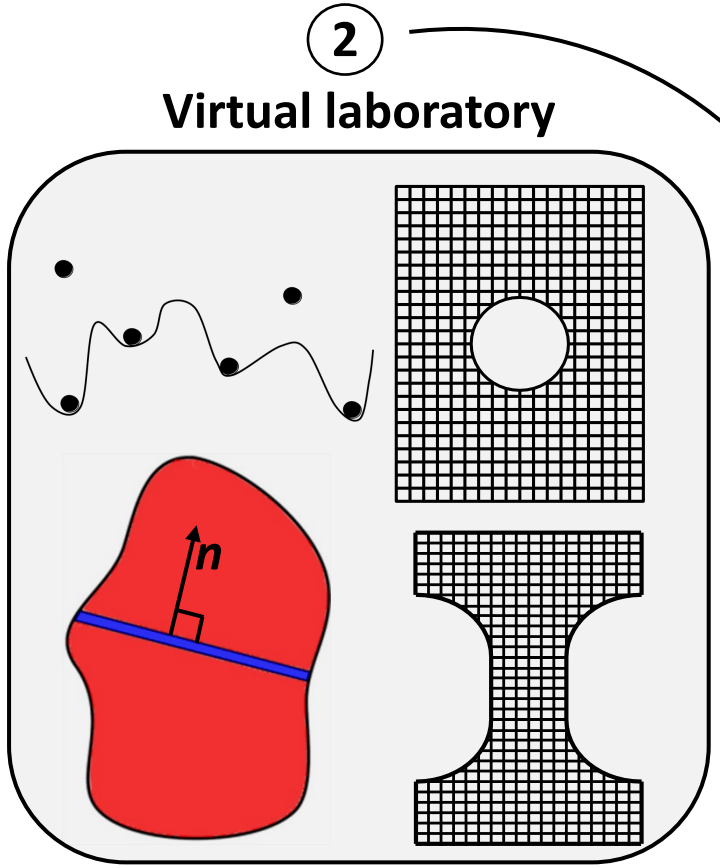
# 1.3. Structural modelling (relevant loading scenarios)

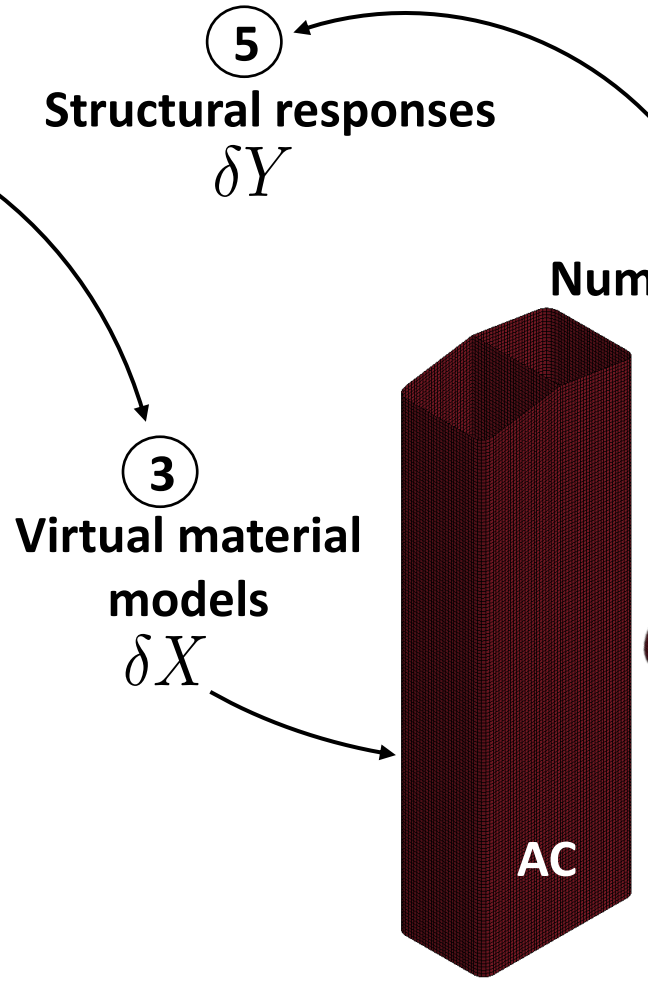


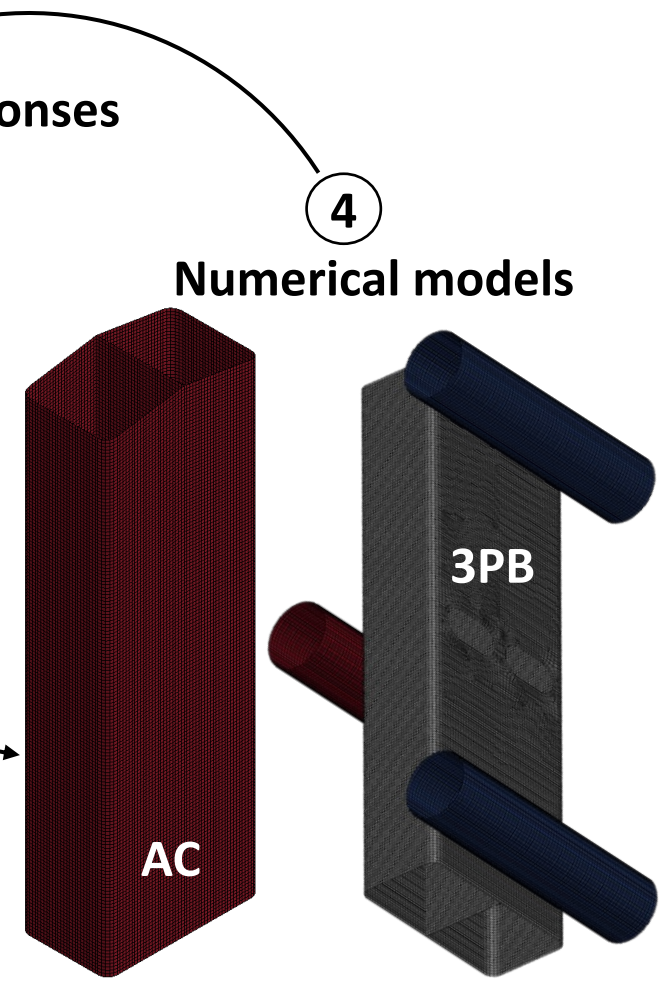
# 2.1. Introduction to PART I (general overview)

- **Goal** → Study the **effects of variations** in **mechanical properties** (**yield stress**, **work hardening**) in **large-scale analyses** of **extruded aluminium profiles** under **axial crushing** and **three-point bending**

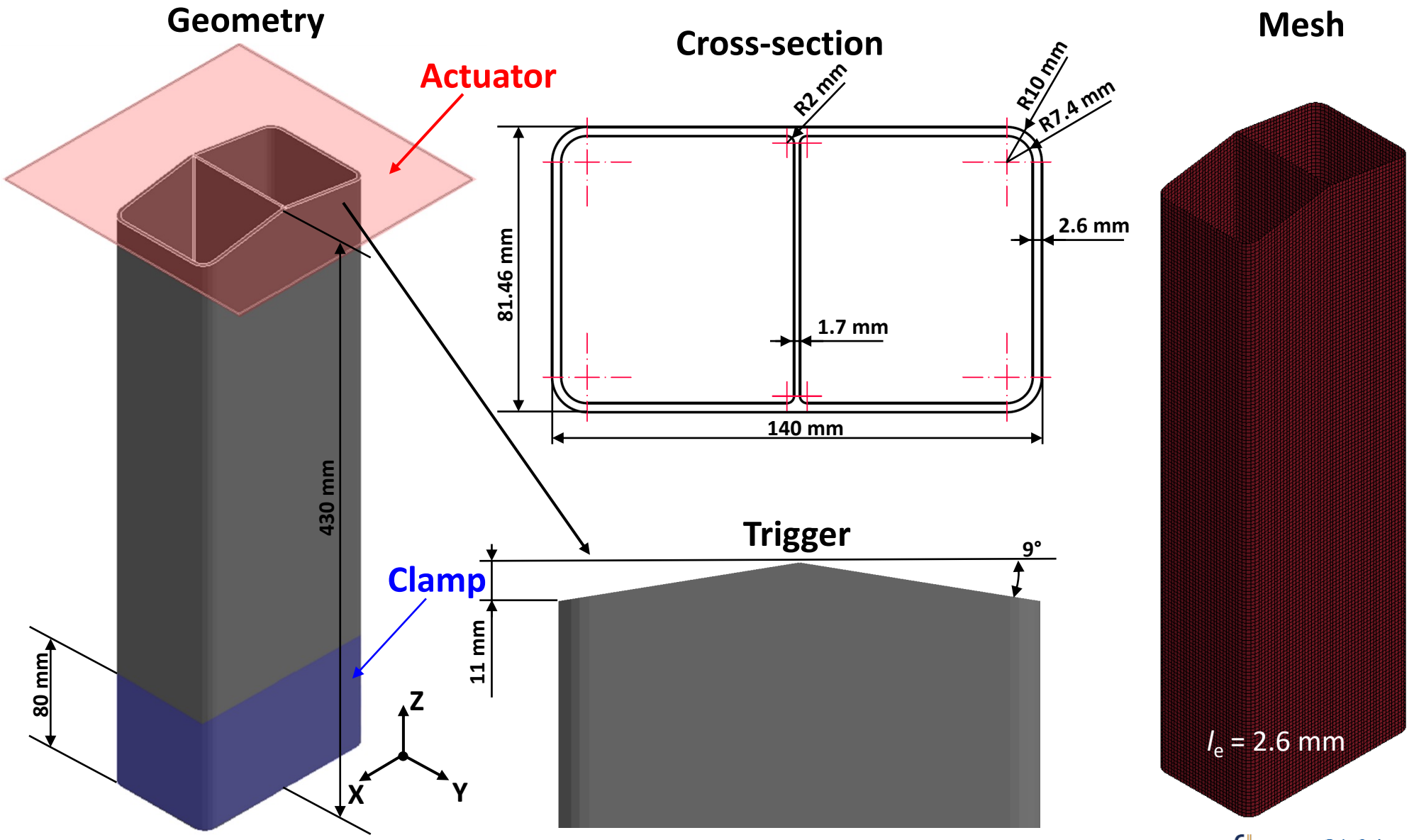


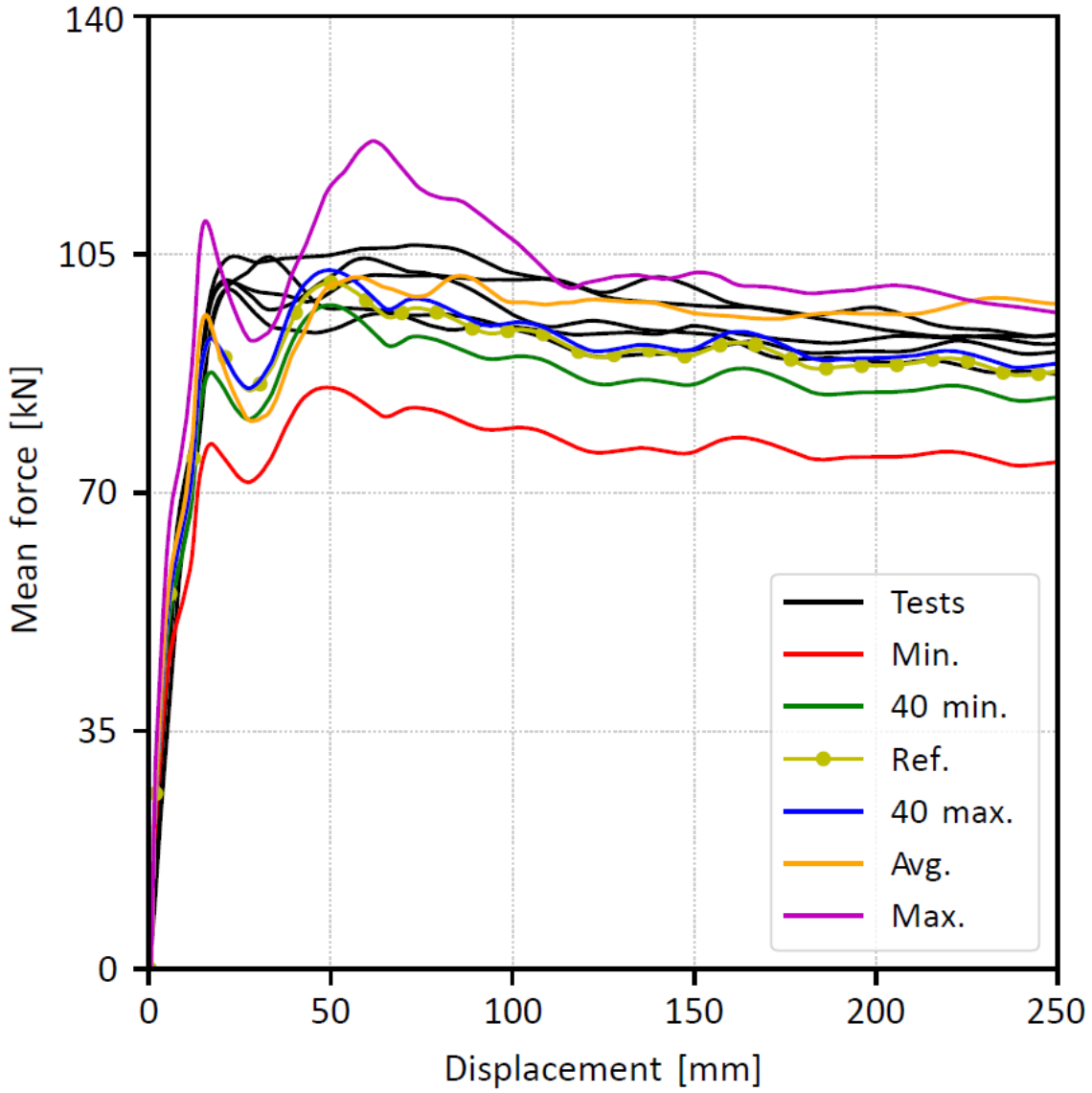



# 2.2. Numerical simulations (FEM)



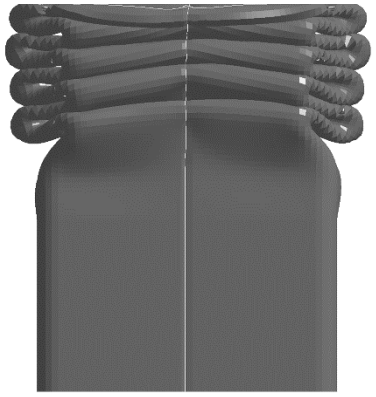
# 2.2. Numerical simulations (forces & deformed shapes)

## Mean forces

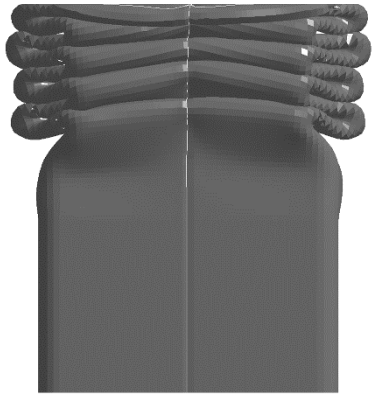



## Deformed shapes

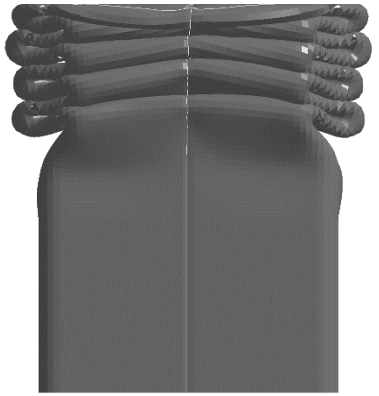
Reference



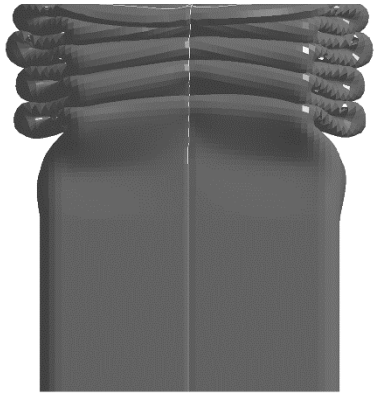
AA6005 min.



AA6005.40 min.

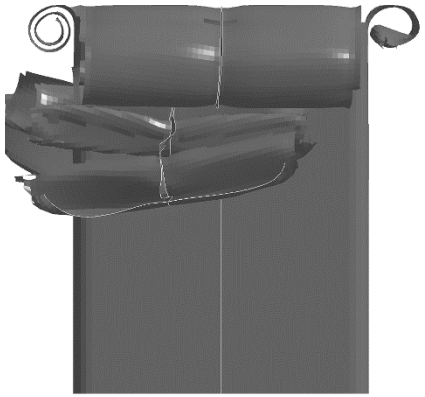


AA6005.40 max.



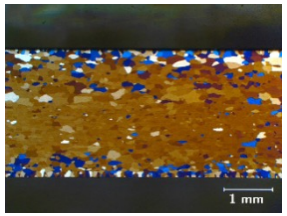
AA6005 avg.

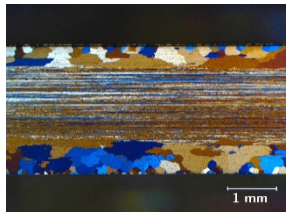
AA6005 max.

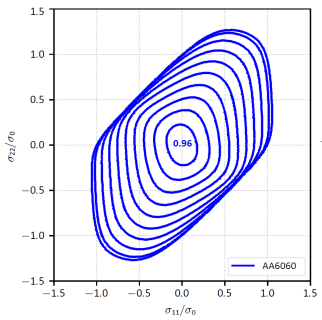


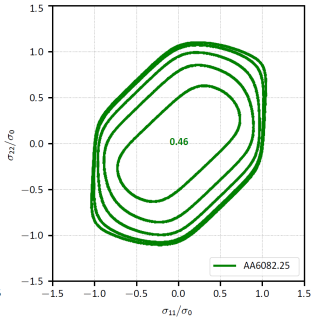
# 3.1. Introduction to PART II (general overview)

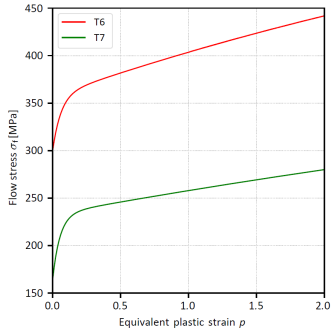
- **Goal** → Study the **effects of variations** in **plastic and failure anisotropy** in **large-scale analyses** of the **same extruded aluminium profiles** as in **PART I**



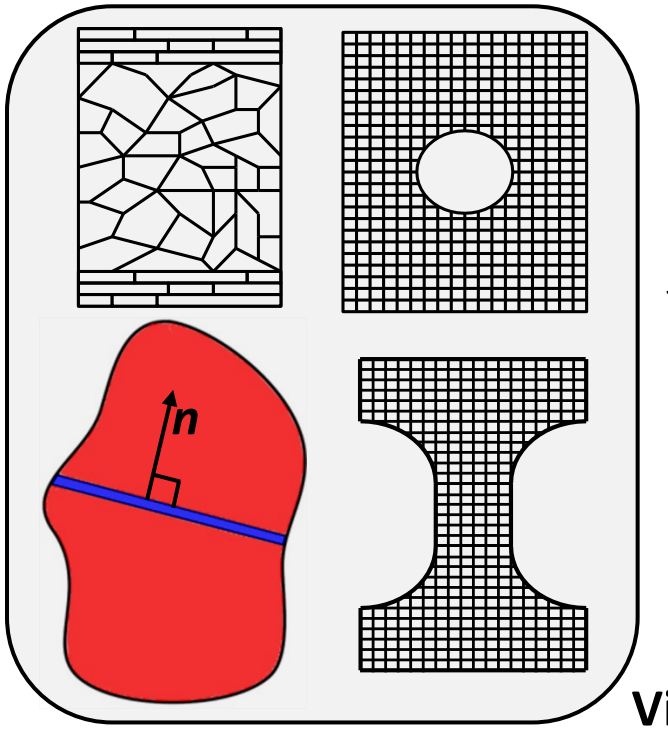




1 **Experimental data (CP-FEM)**

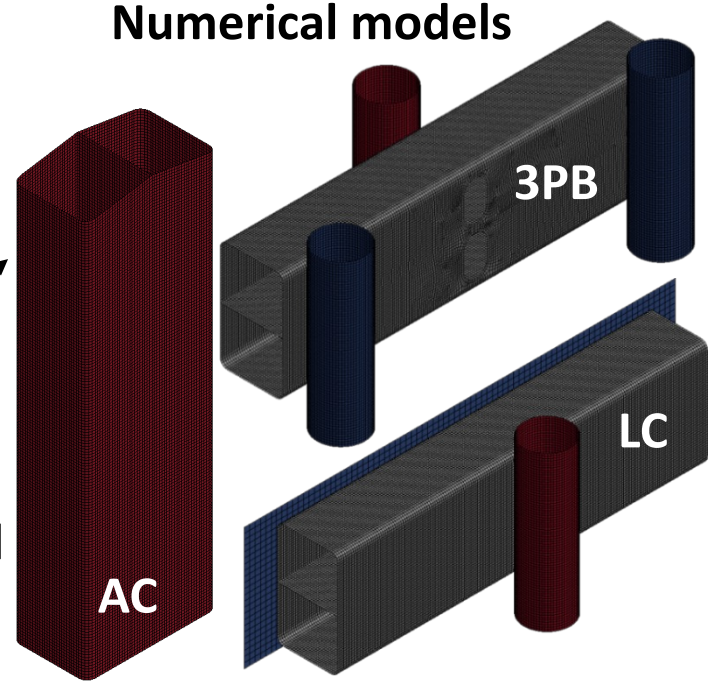
2 **Relevant material models**

3 **Virtual laboratory**




4 **Virtual material models** $\delta X$

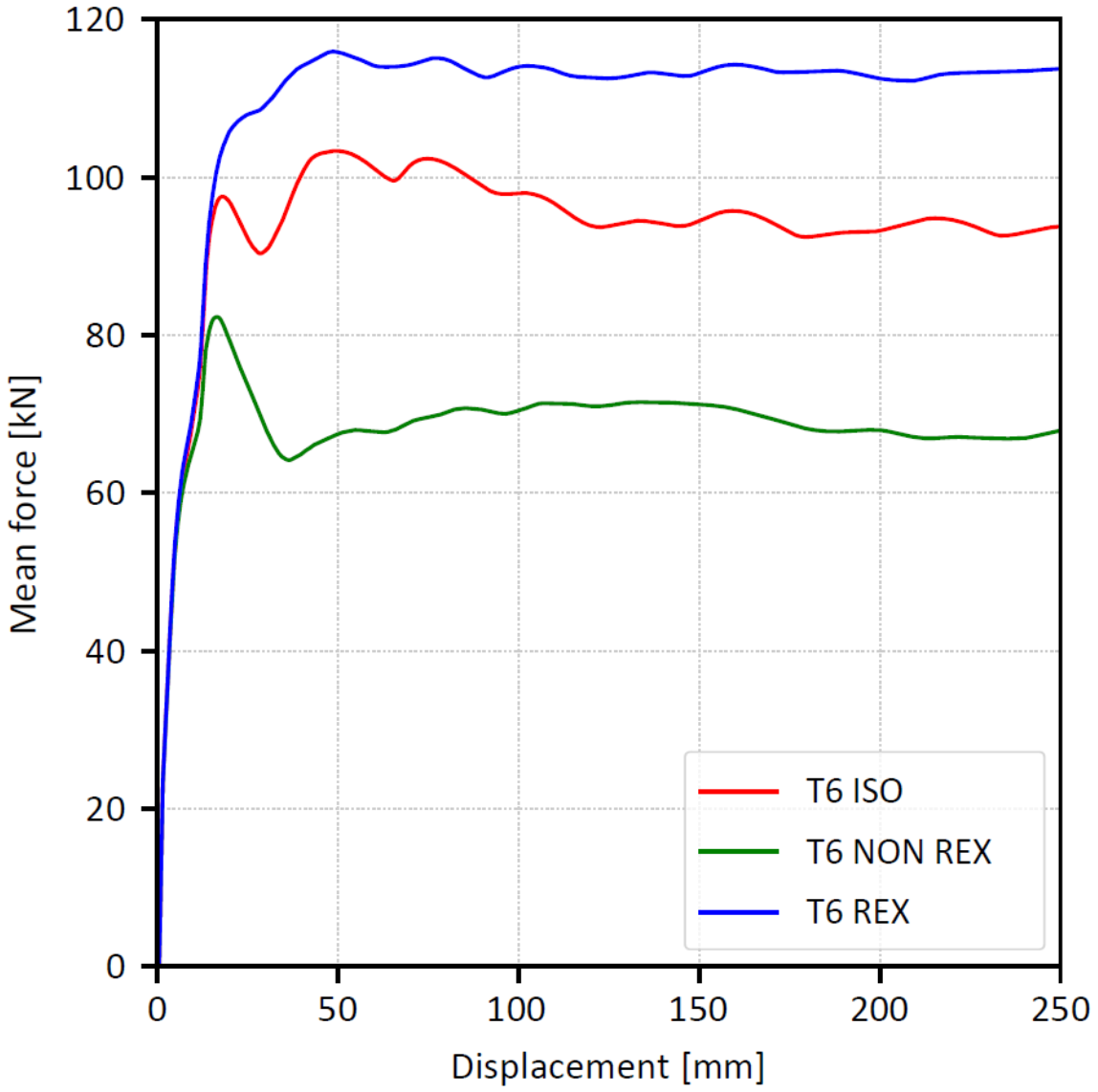
5 **Numerical models**




6 **Structural responses** $\delta Y$

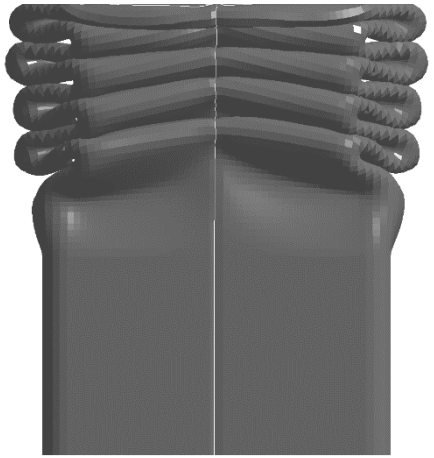
# 3.2. Numerical simulations (forces & deformed shapes)

## Mean forces



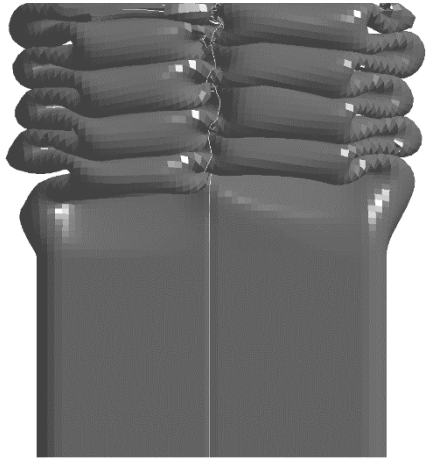

## Deformed shapes

T6 ISO



T6 NON REX

T6 REX



# 4. Final conclusions and future work

- **Final concluding remarks**:
  - Considering **variations** in the **chemical composition**, **plastic** and **failure anisotropy** in **finite element simulations** certainly **influence** the results
  - It is believed that this thesis will help to **improve** the **state of the art** of for **large-scale modelling** and **simulation** of **energy absorbing structures** for **industrial applications**
- **Future work**:
  - Include **other variations in geometry.** Use **different material models** for both the inner and outer wall
  - **Extend the effects** of variation in plastic and failure anisotropy. Apply the **VL to joints**

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