

Simulation based distortion management for multiple stage assembly of welded structures

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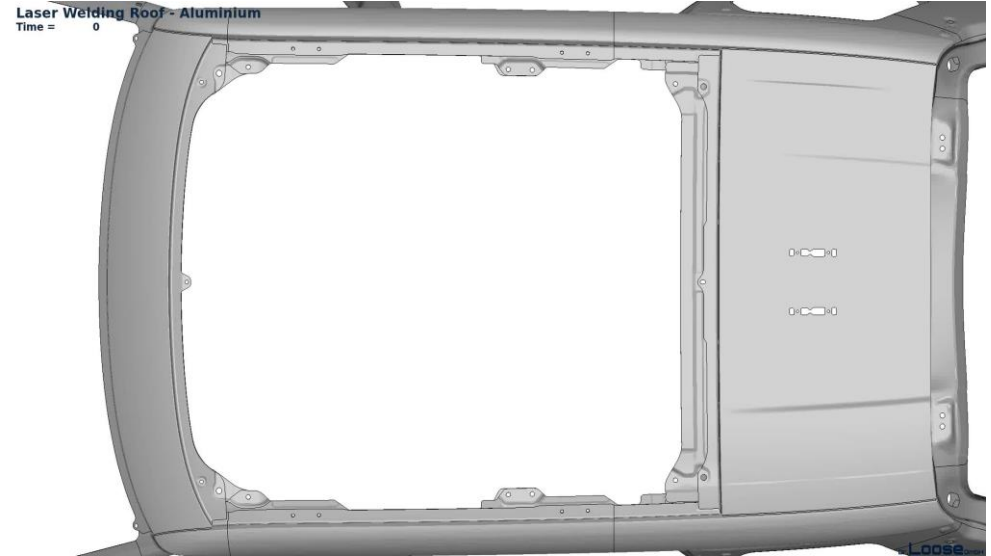


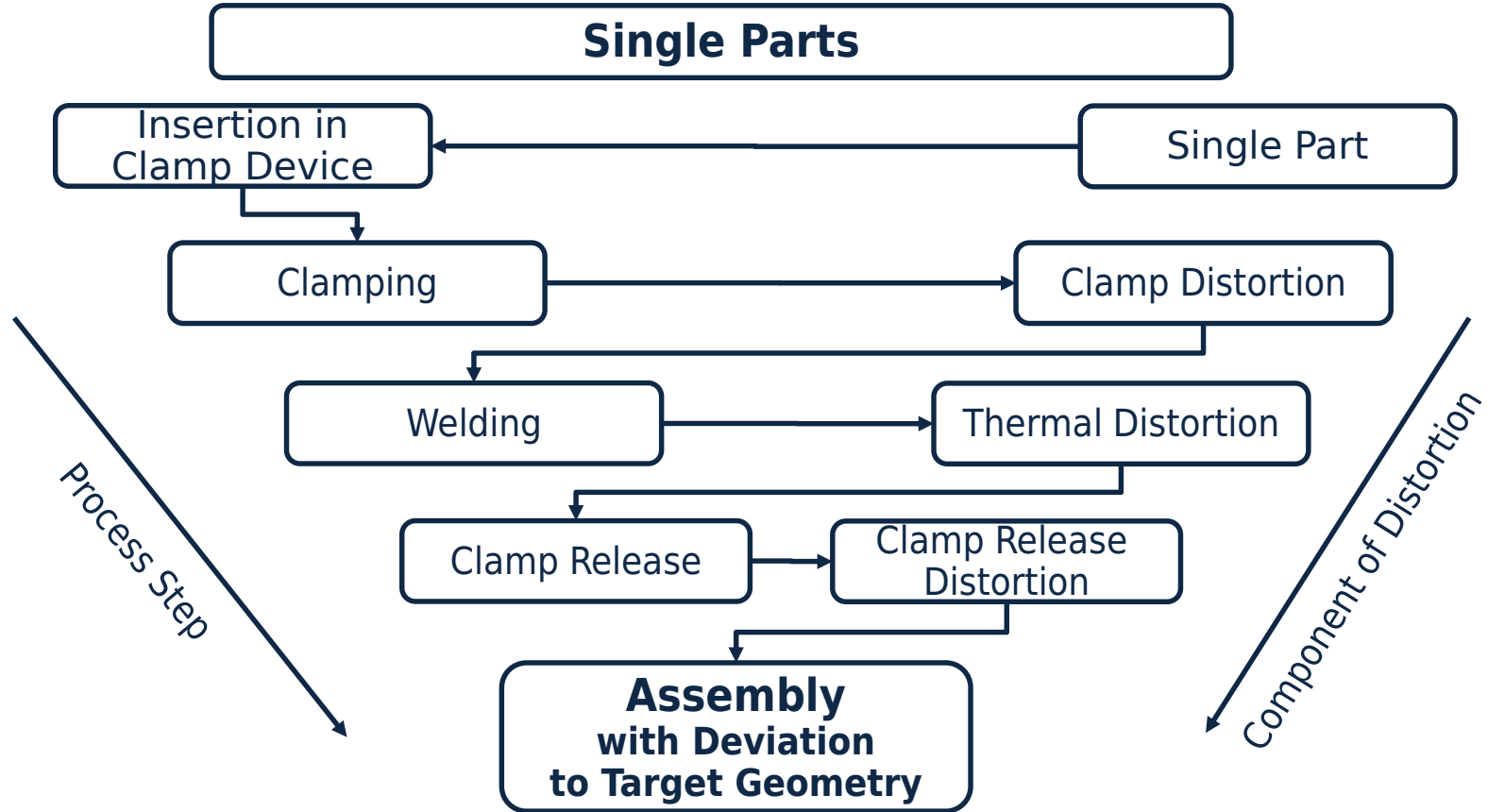
Introduction

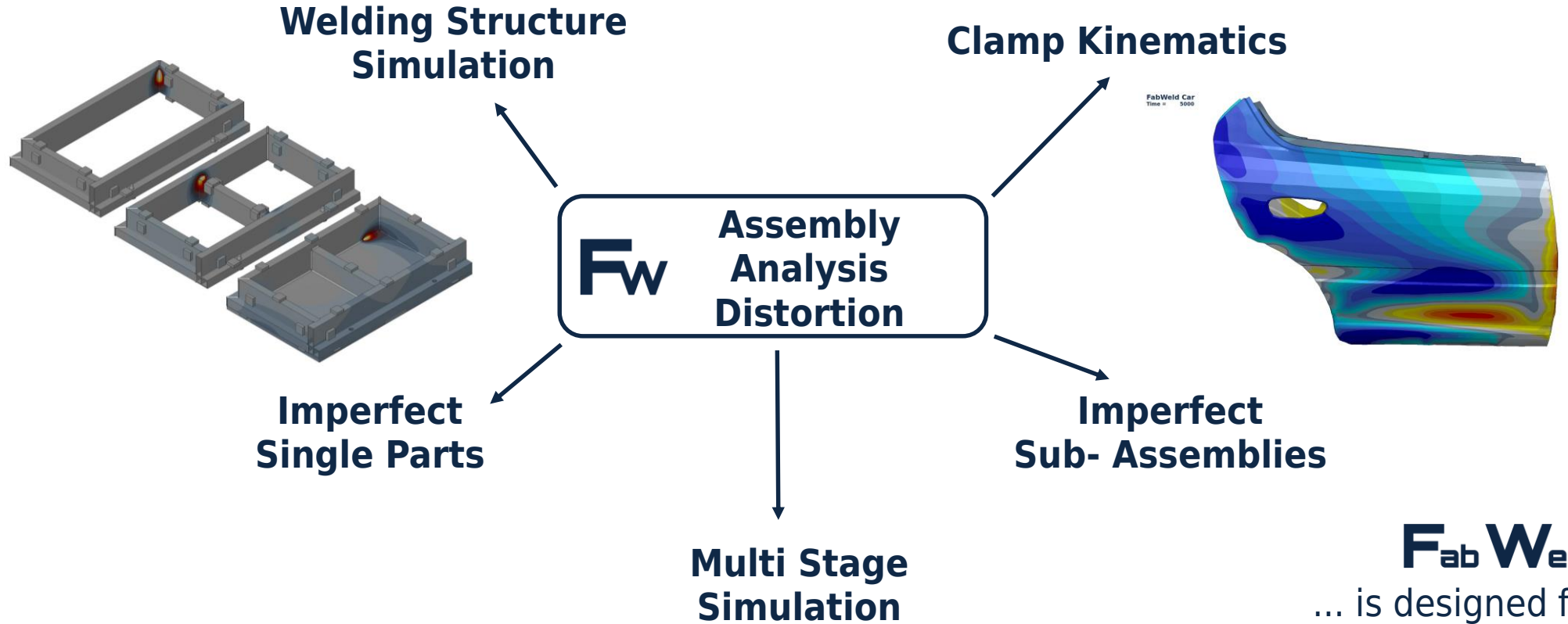
Save cost and time
during design and development
of production lines for new vehicles.



Source: Jaguar Land Rover

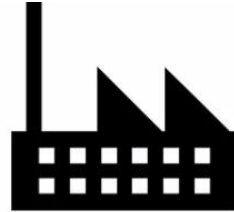






F_{ab} Weld
... is designed for
Assembly Analysis

- **Assembly simulation of welded structures provides:**
- Proof of concept at an early stage of design
- Understanding of the process
- Discover sensitivities welding, clamping, geometry
- Detection of assembly issues
- Improved product quality
- Straight forward design of process and manufacturing line
- Design of improvements to keep deformation within tolerance
- Go virtual and save many try out loops in shop floor



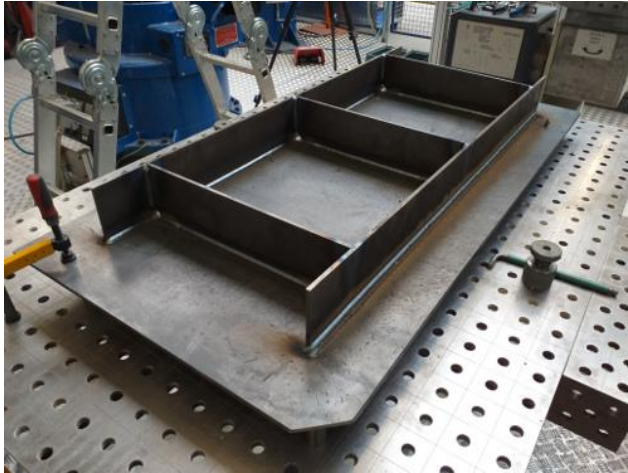
Source: Jaguar Land Rover

Achieve 100 % Right First Time

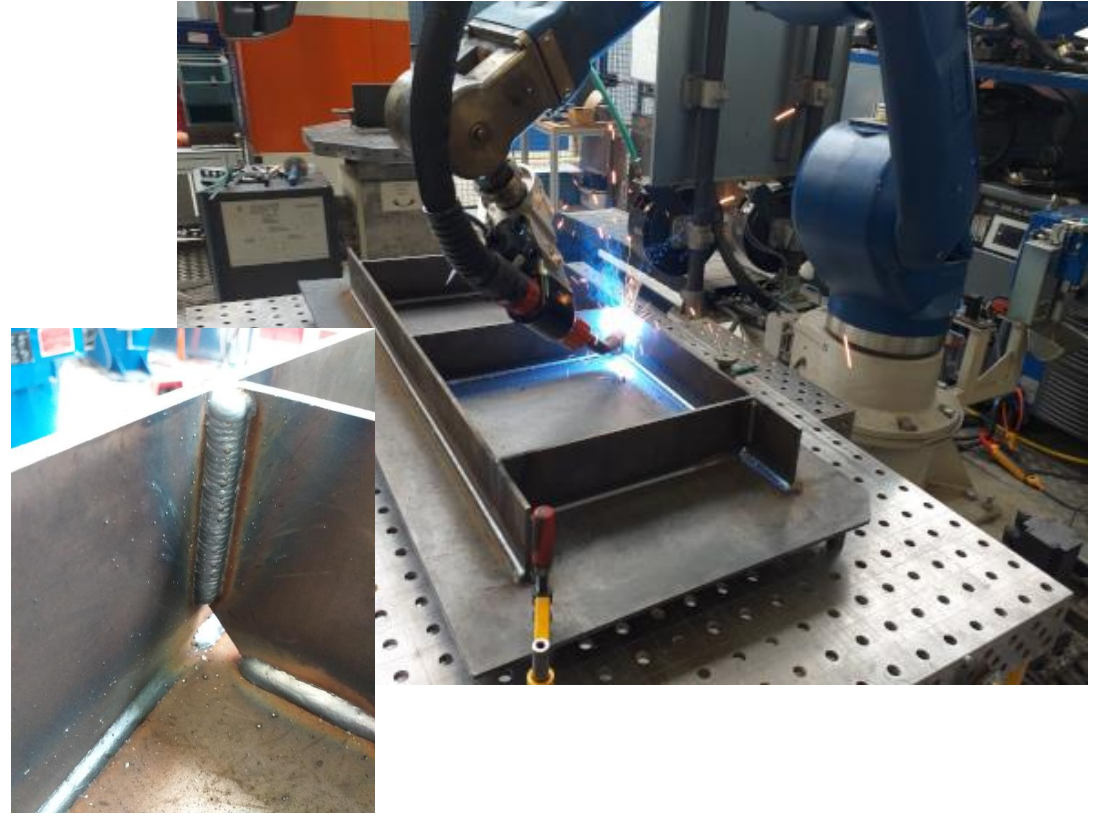


Validation

Consider all relevant physical effects
Keep close to reality
Get right results



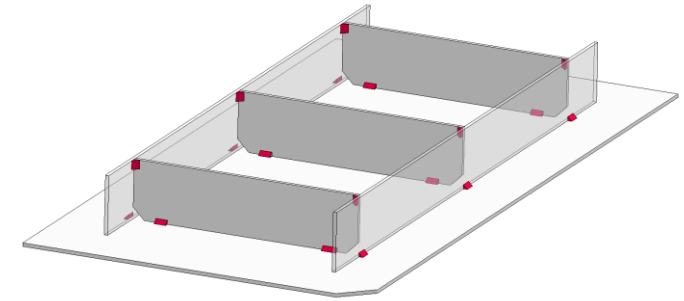
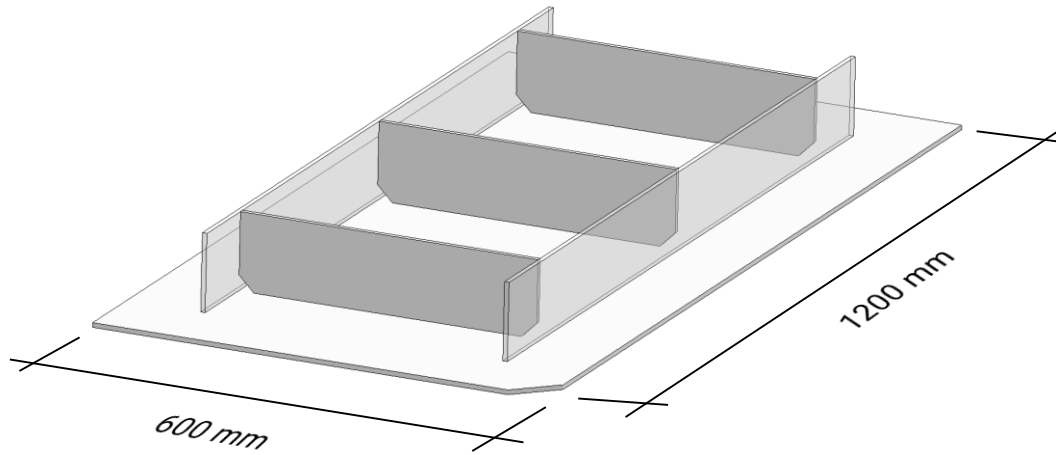
At each state of the
welding process



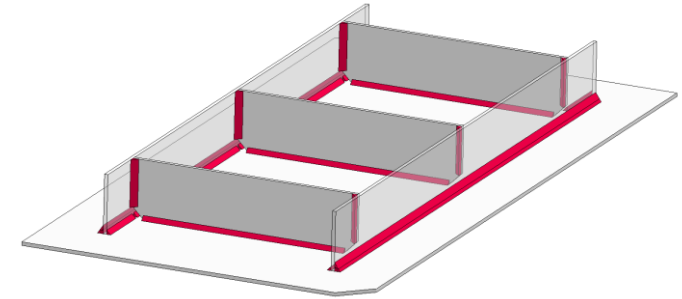


Overview

- 18 tack welds
- 2 supports, removed after tack-welding
- 2 multi pass welds (three-layered)
- 17 single pass welds (fillet weld)



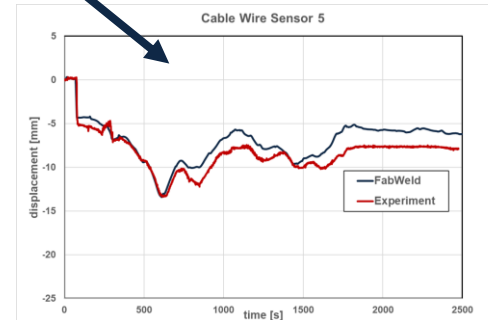
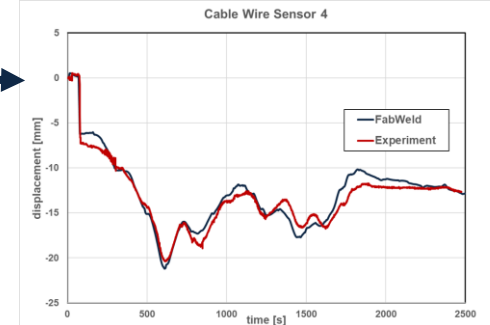
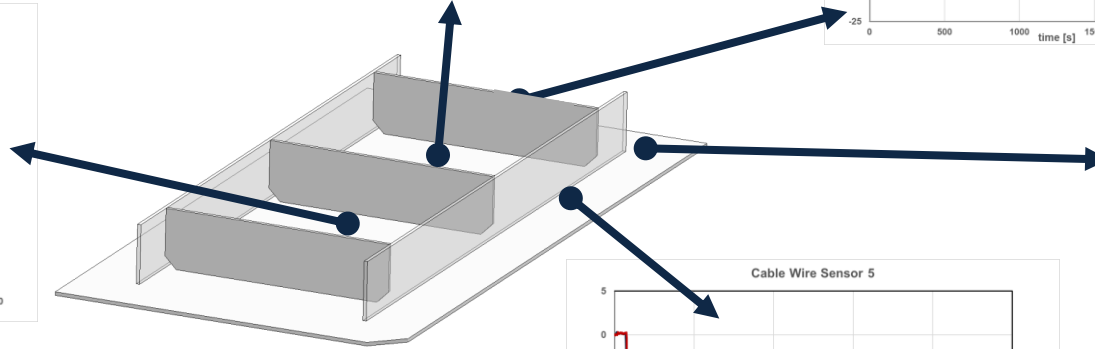
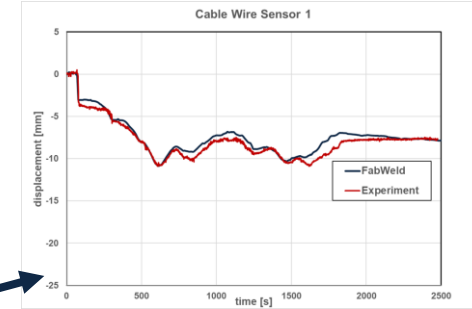
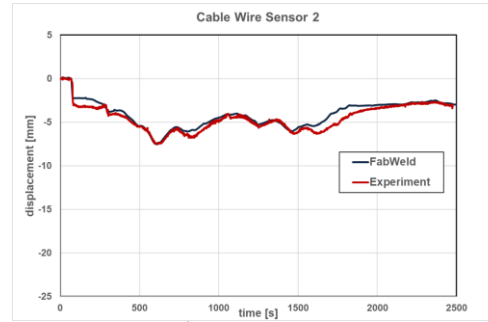
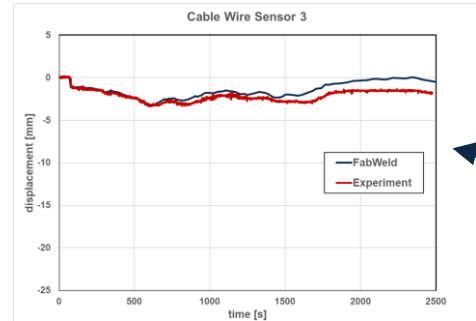
Tacks



Welds

Displacement over time

red: Experiment
blue: Simulation



Very good agreement between experiment and calculation is achieved throughout the process.



Demonstator - Battery Tray

Capability of Simulation and Results

FabWeld Demonstrator Battery Tray

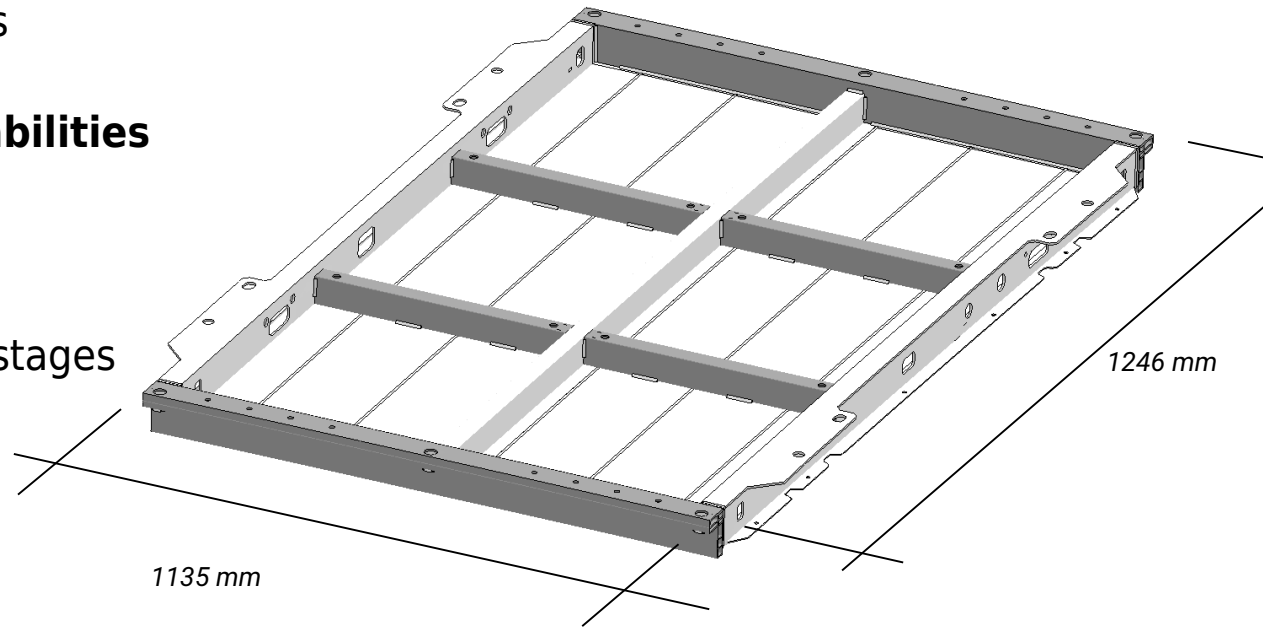
Made of AlSi7Mg aluminum profiles state T6

Assembly in 4 stages including subassemblies

Welding process: Fronius CMT 10 mm/s

Demonstration of Simulation Capabilities

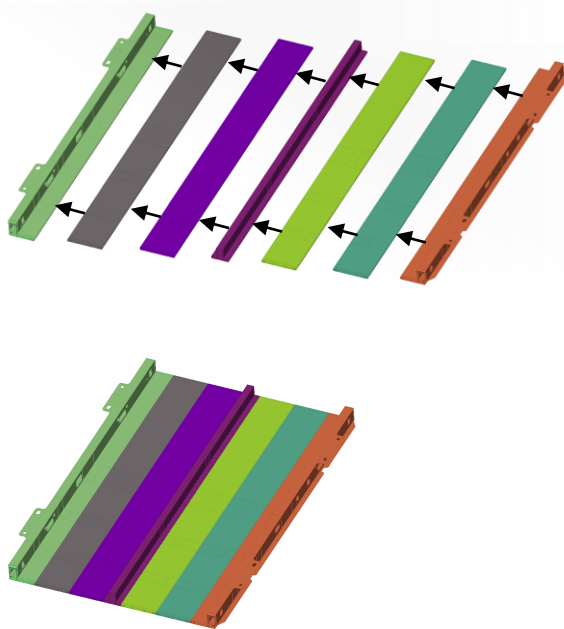
- Capturing the entire process
- Assembly and sub-assembly
- Clamps and tooling
- Consider imperfections from prior stages
- Predict deformation
- Discover improvement potentials



Assembly Sequence

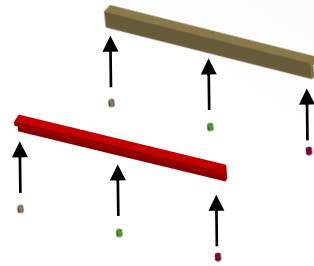
GEO Station 1.1

Welding of bottom plates



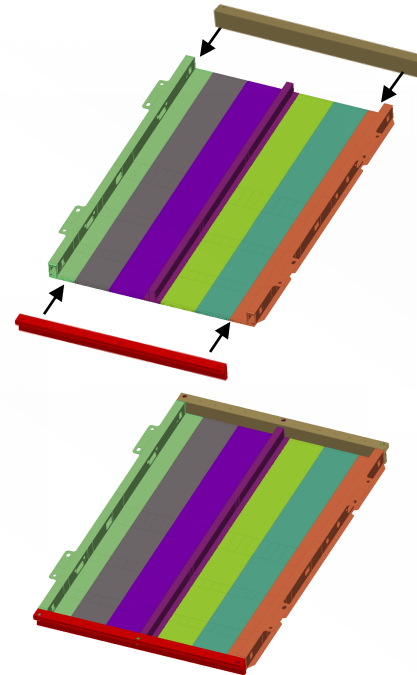
Station 1.2 Subassembly

Welding of bushes in outer crossmembers



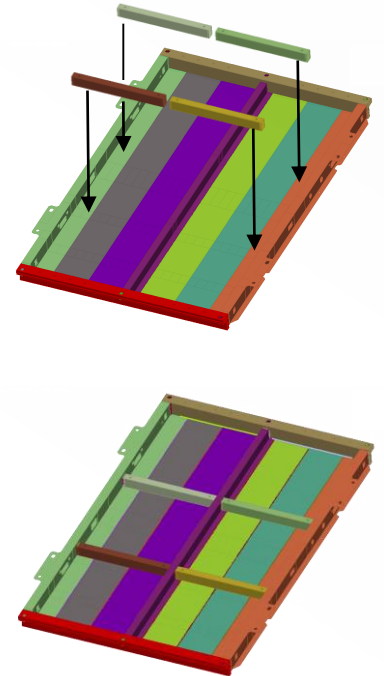
GEO Station 2

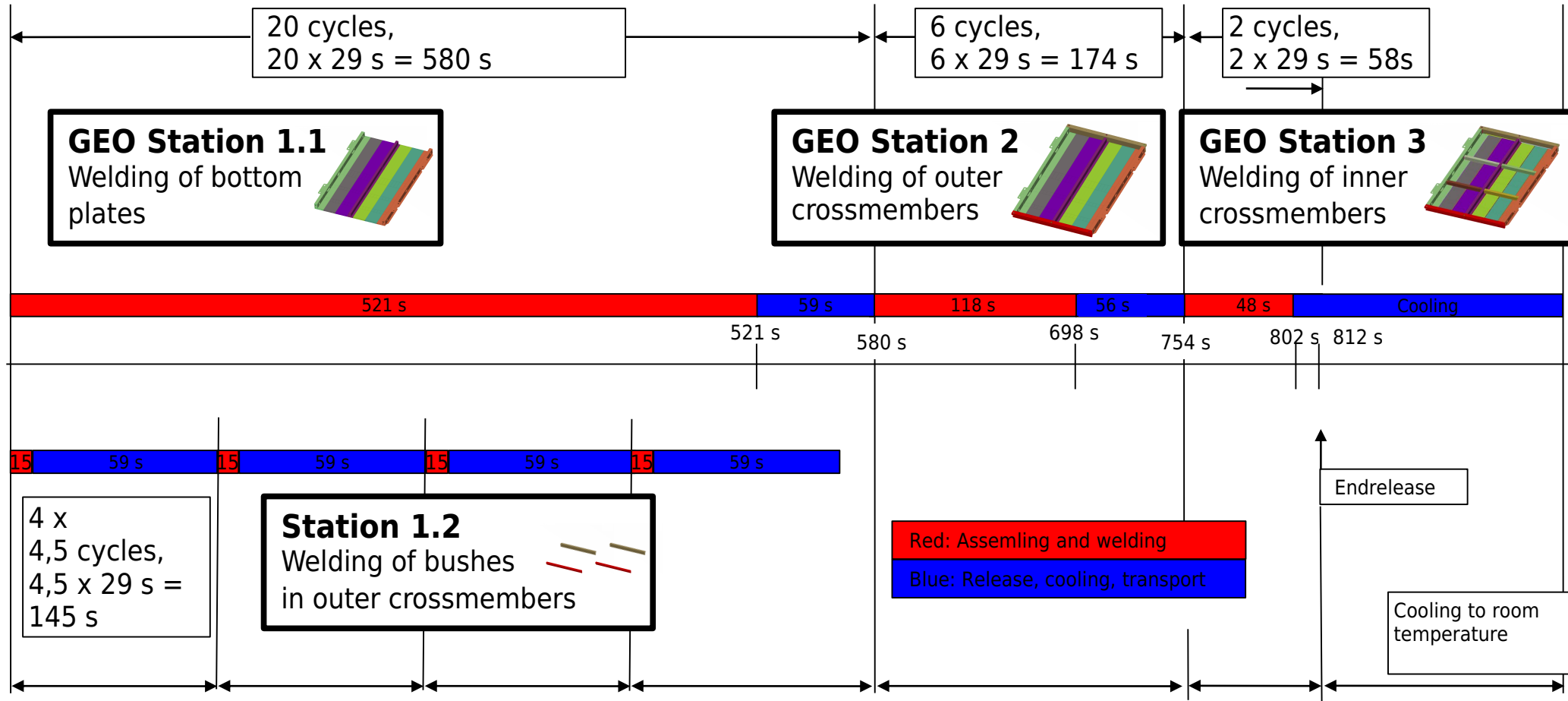
Welding of outer crossmembers and bottom



GEO Station 3

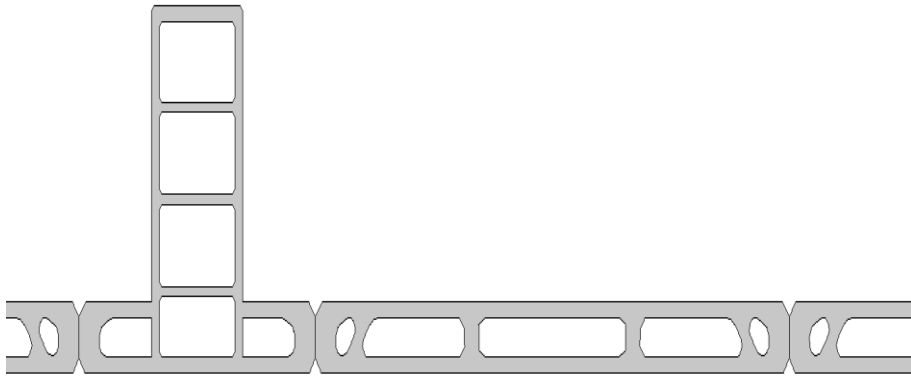
Welding of inside crossmembers



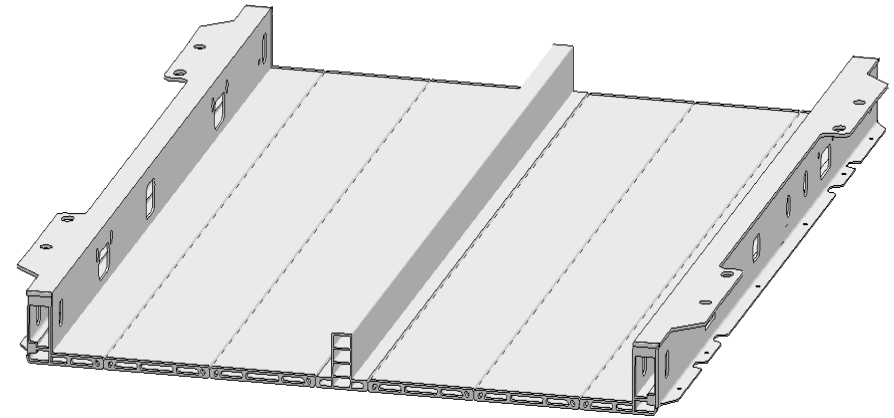


Battery tray aluminium extrusion profiles

Cross section

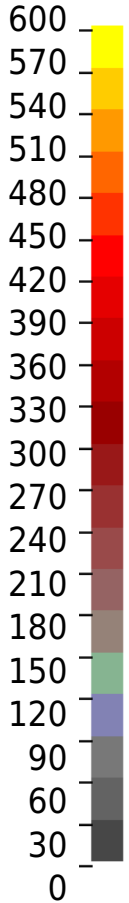
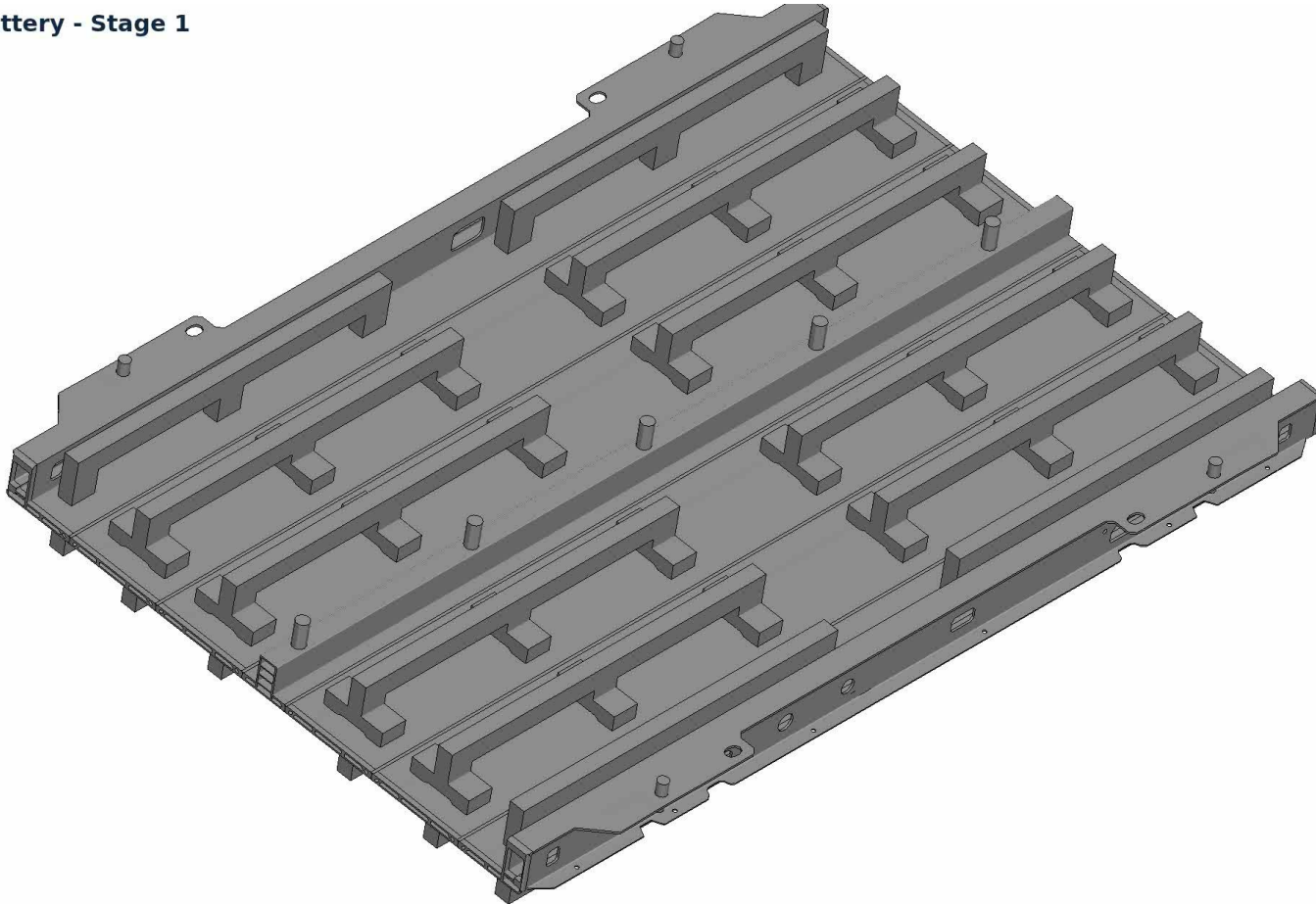


3-dimensional view



Profiles of aluminium alloy AlSiMg in T6-state

FabWeld Battery - Stage 1



Z-distortions -2.5 - 2.5 [mm]

clamped

unclamped

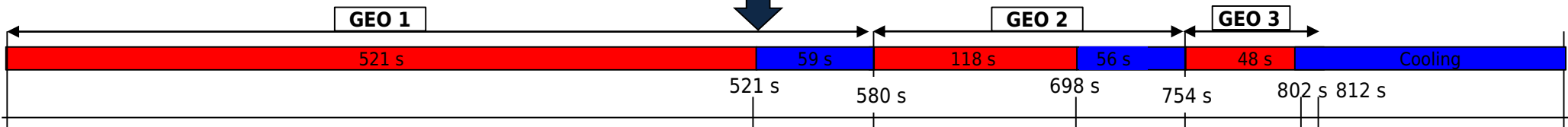
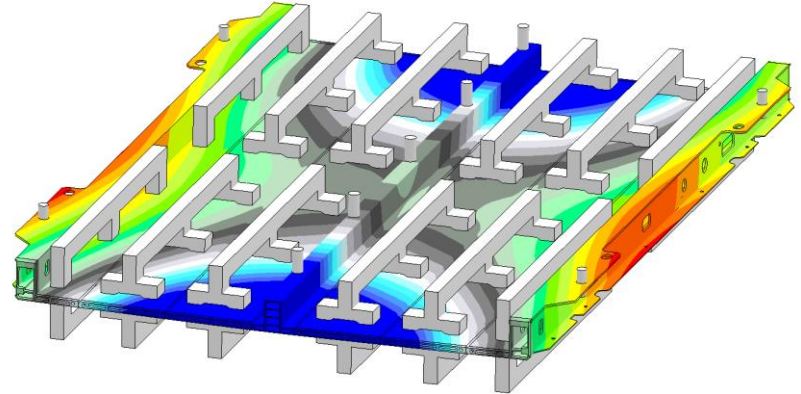
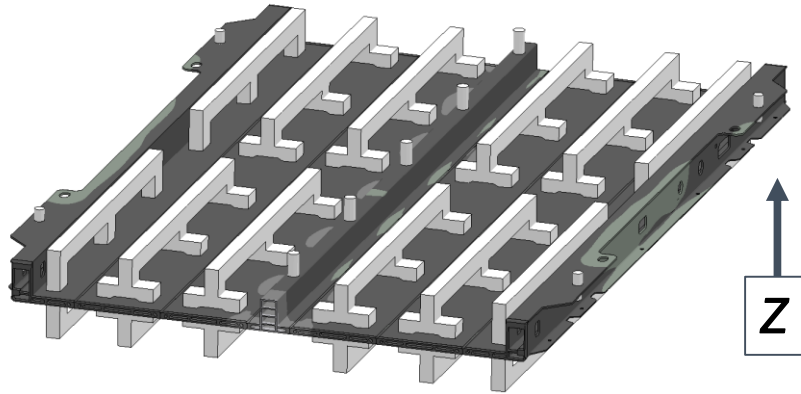
Time = 530

Z-displacement Time = 530.1

Z-displacement

2.500e+00
2.262e+00
2.024e+00
1.786e+00
1.548e+00
1.310e+00
1.071e+00
8.333e-01
5.952e-01
3.571e-01
1.190e-01
-1.190e-01
-3.571e-01
-5.952e-01
-8.333e-01
-1.071e+00
-1.310e+00
-1.548e+00
-1.786e+00
-2.024e+00
-2.262e+00
-2.500e+00

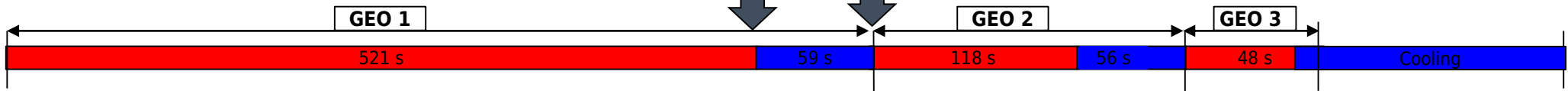
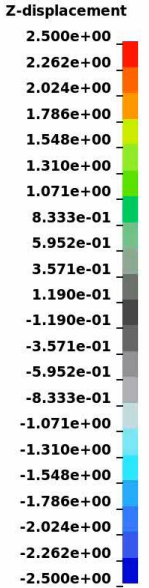
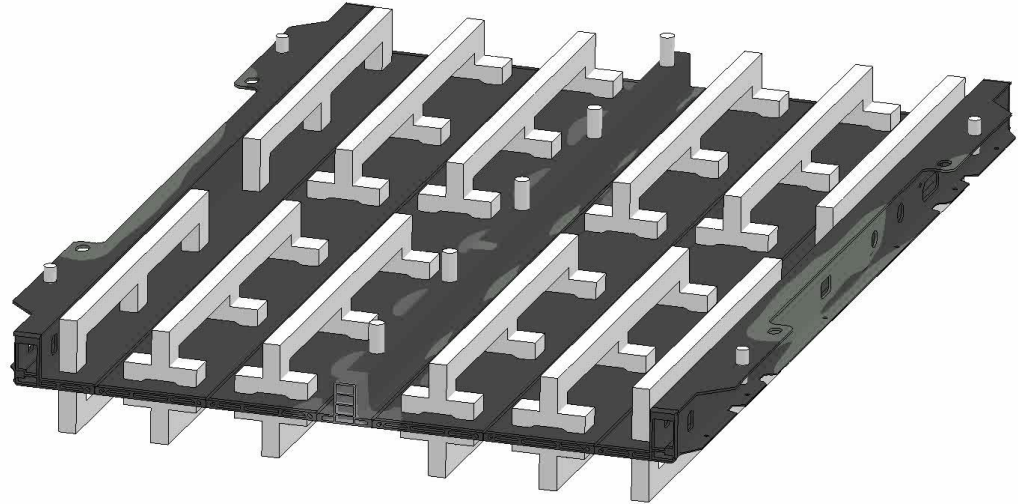
2.500e+00
2.262e+00
2.024e+00
1.786e+00
1.548e+00
1.310e+00
1.071e+00
8.333e-01
5.952e-01
3.571e-01
1.190e-01
-1.190e-01
-3.571e-01
-5.952e-01
-8.333e-01
-1.071e+00
-1.310e+00
-1.548e+00
-1.786e+00
-2.024e+00
-2.262e+00
-2.500e+00



Unclamping Geo Station 1.1

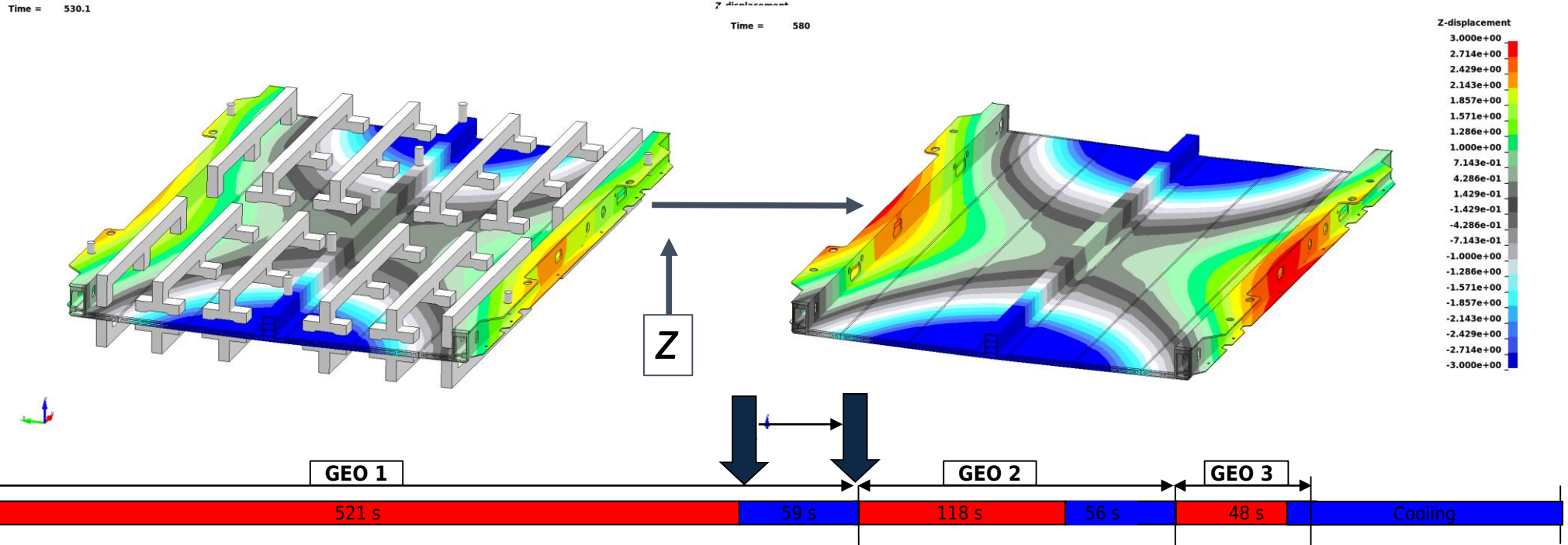
Time = 530

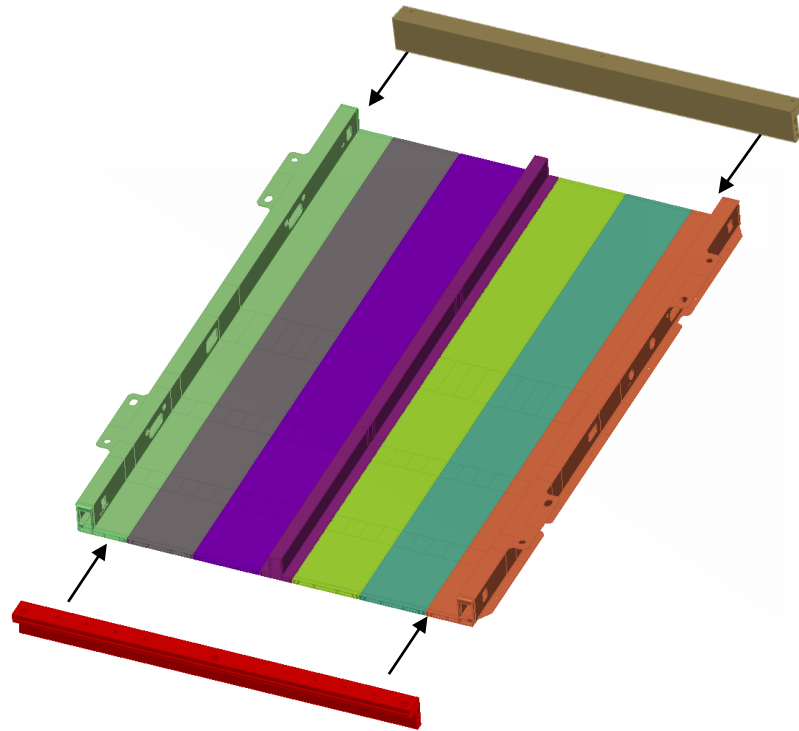
*Z-distortions
from clamped to unclamped
and intermediate cooling*



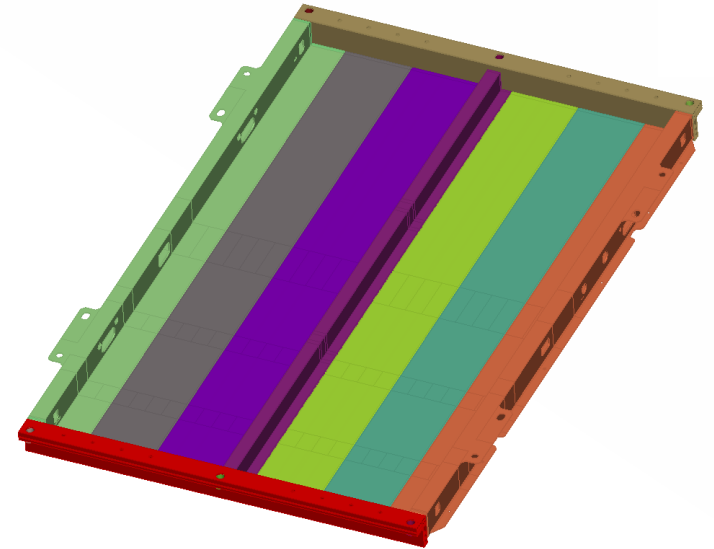
Z-distortions from unclamping to end of intermediate cooling

Z-distortions -3.0 - 3.0 [mm]



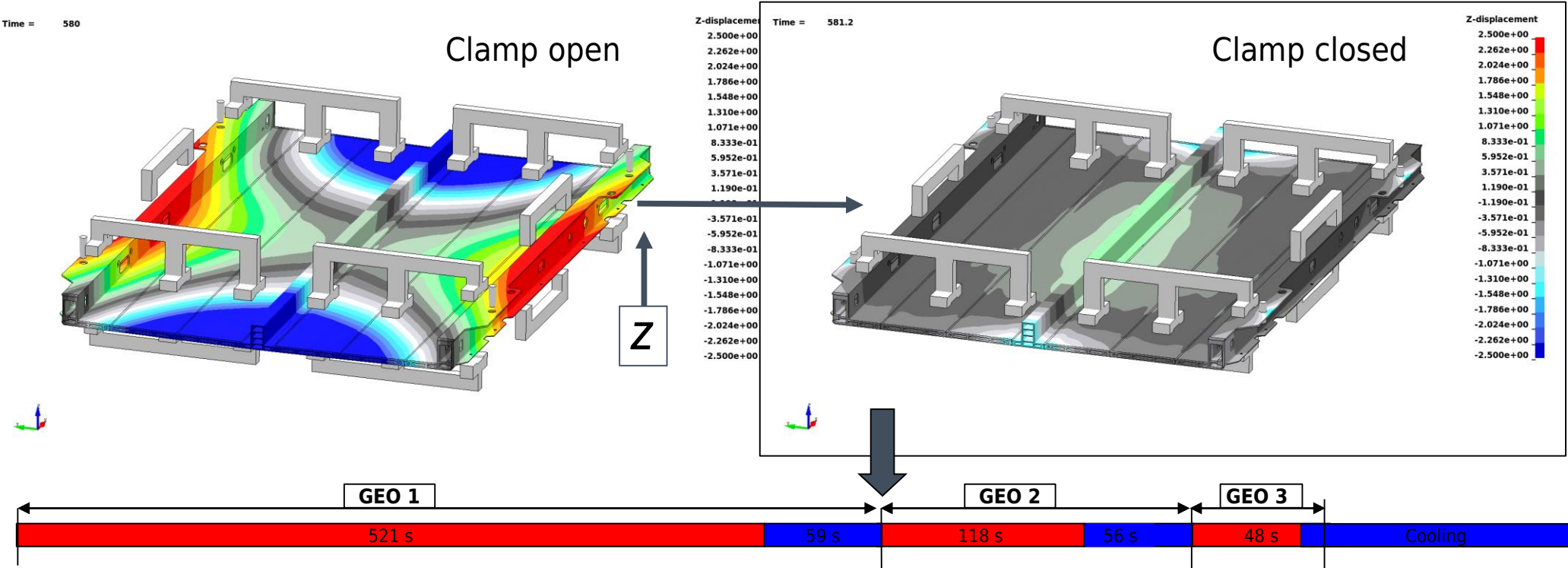


Single components

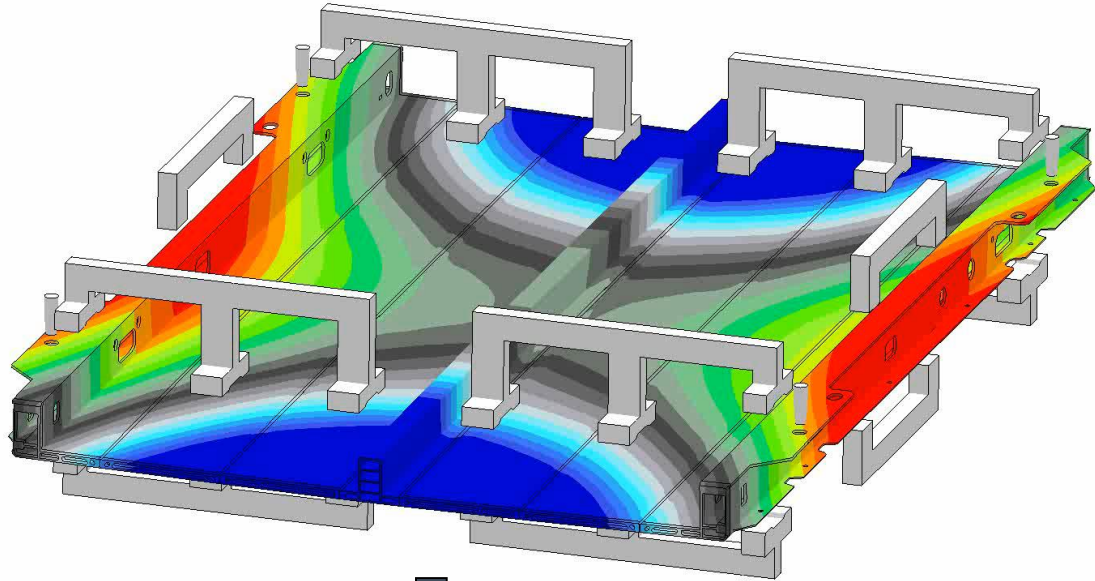


2nd assembly in step 2

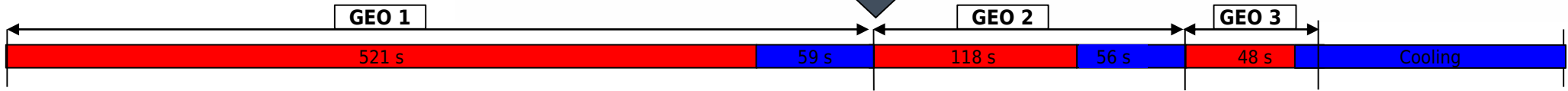
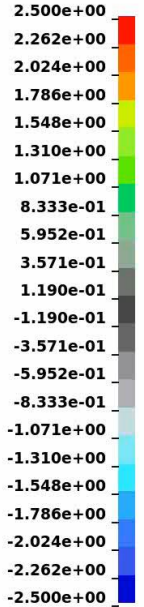
Clamping forces bend back the Z-distortions from previous step

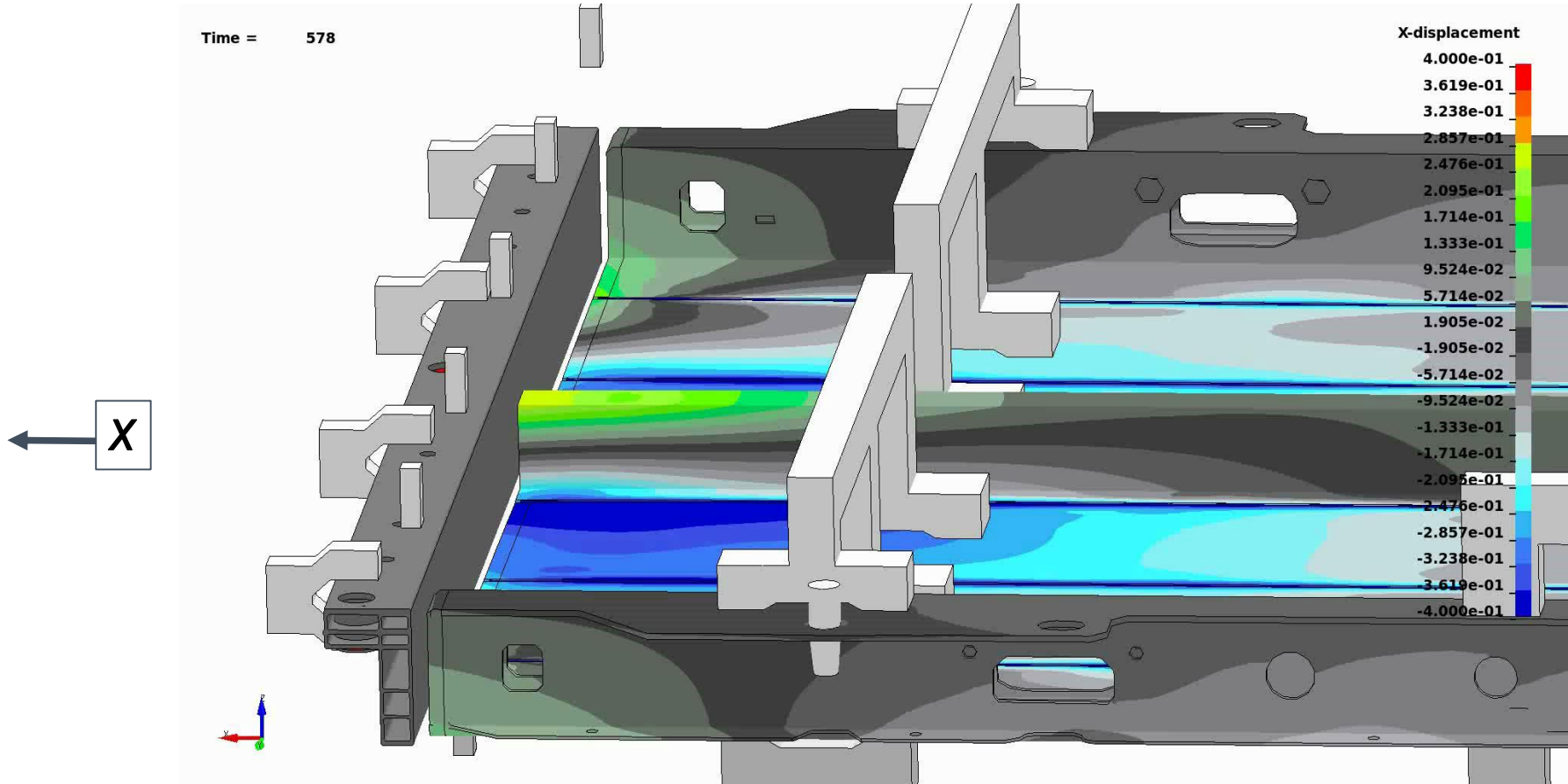


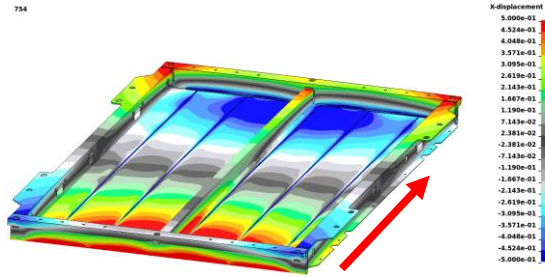
Time = 580



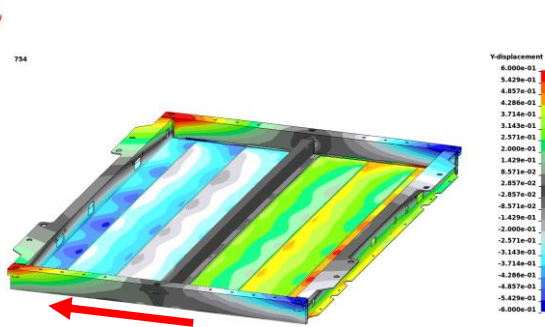
Z-displacement



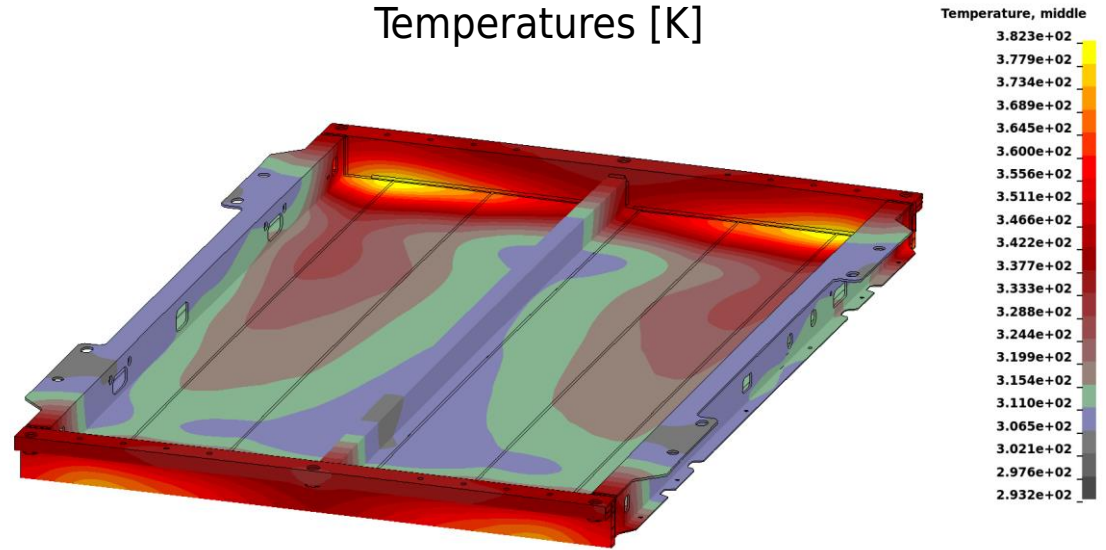




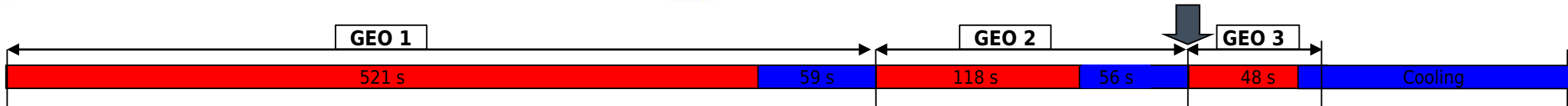
X-distortions
-0.5 - 0.5 [mm]



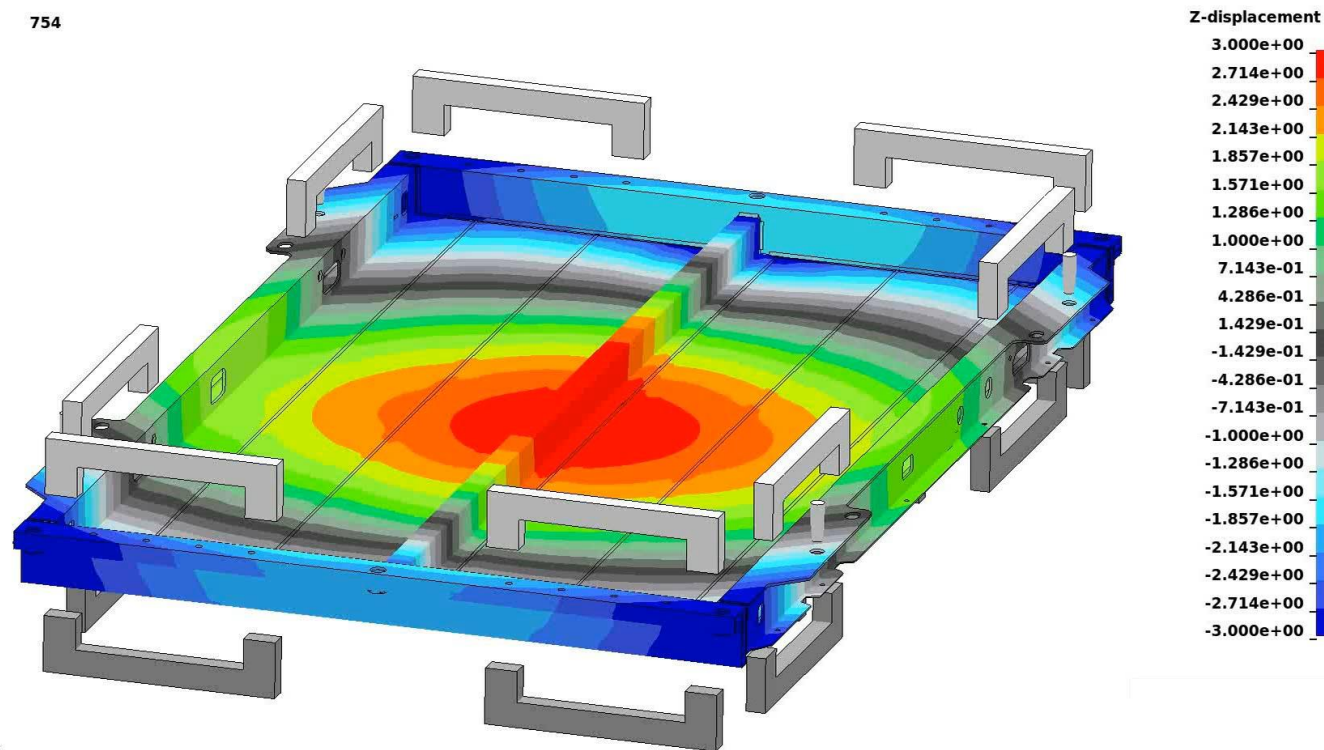
Y-distortions
-0.6 - 0.6 [mm]



Temperatures [K]



Time = 754



GEO 1

521 s

59 s

GEO 2

118 s

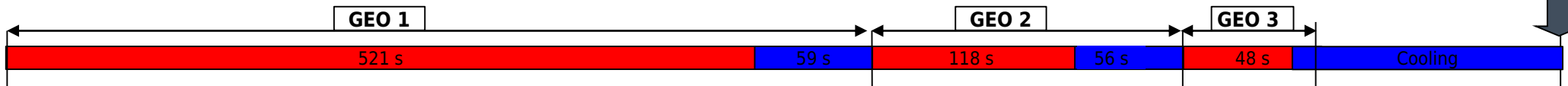
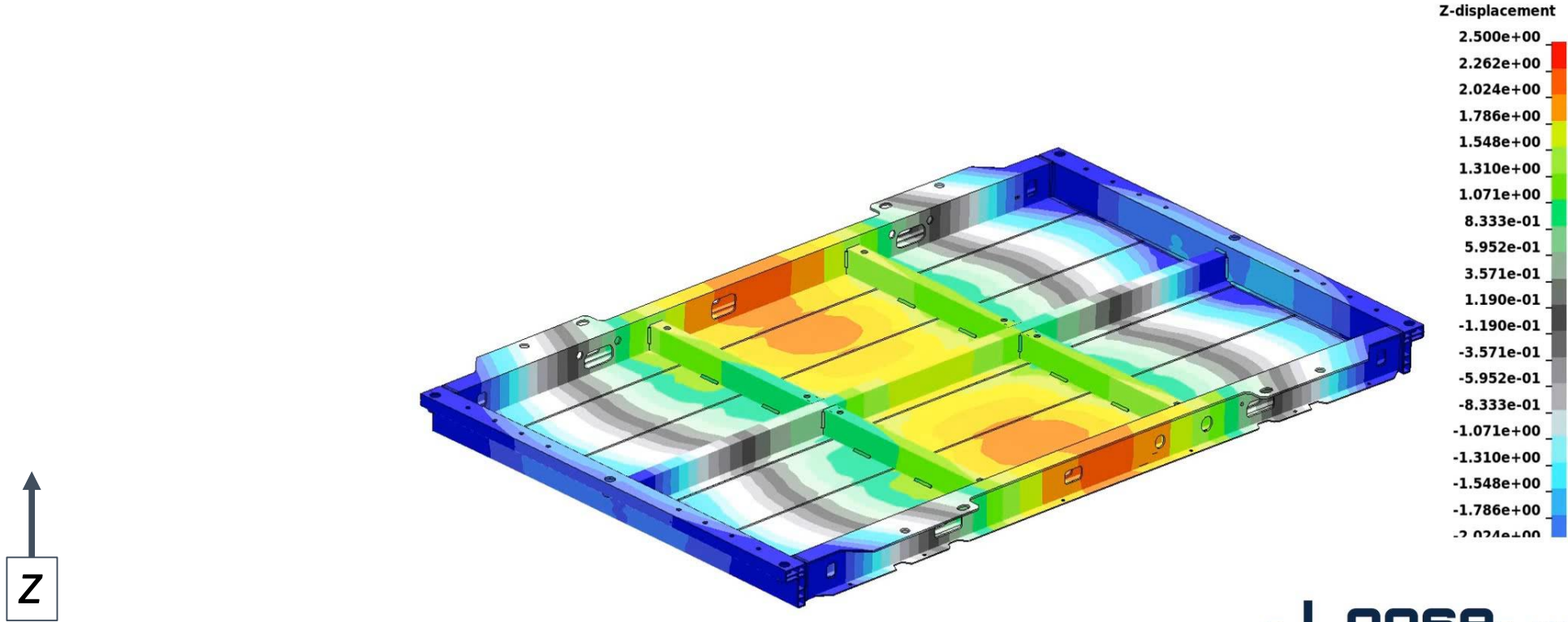
56 s

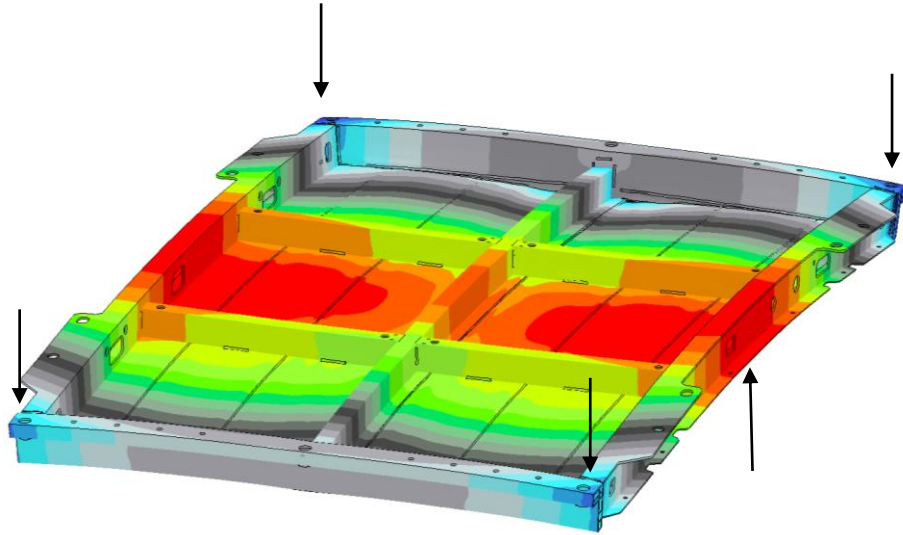
GEO 3

48 s

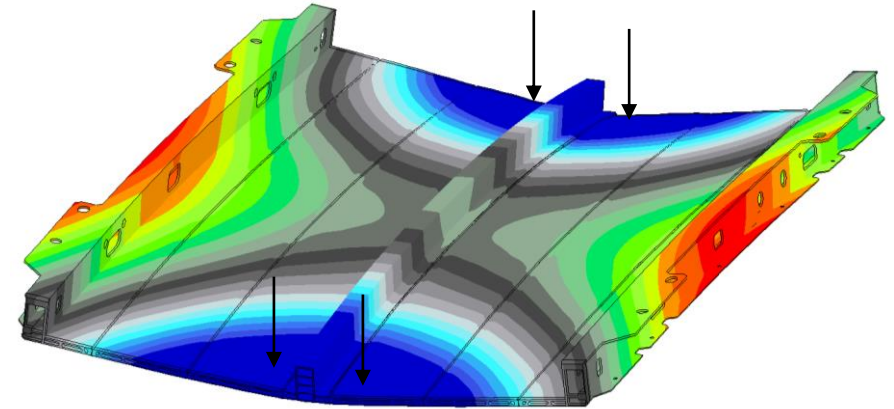
Cooling

Final Distortion after complete Cooling





Entire assembly



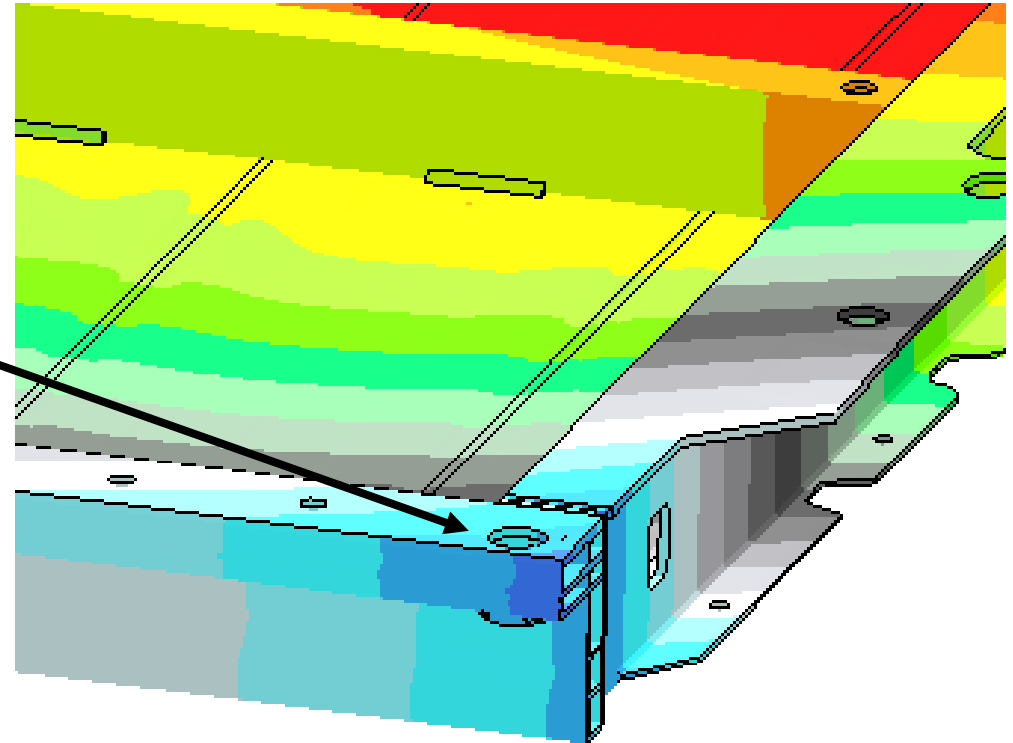
Step1



Main Deviation comes from GEO 1
Thus improvements hast to be applied for GEO 1

Check the deformation

- Matching target tolerances?
- Mounting points violated?
- Fit precision given?
- Visible inaccuracies?



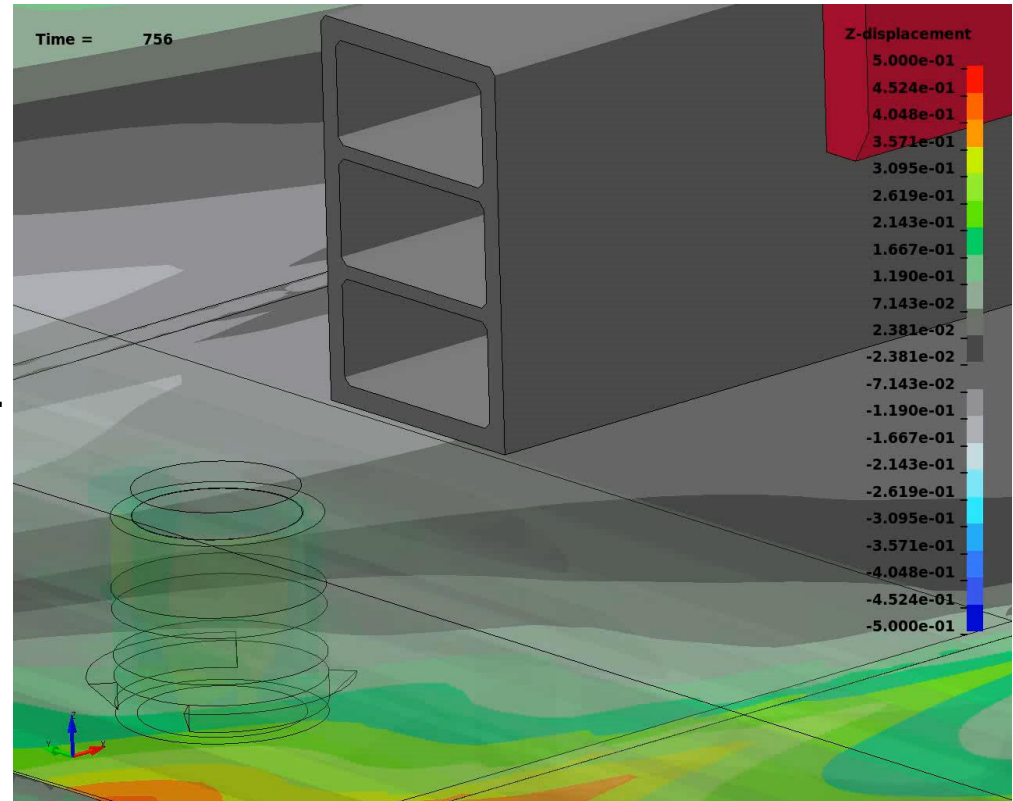
Issues during assembling

Geometrical deviations from

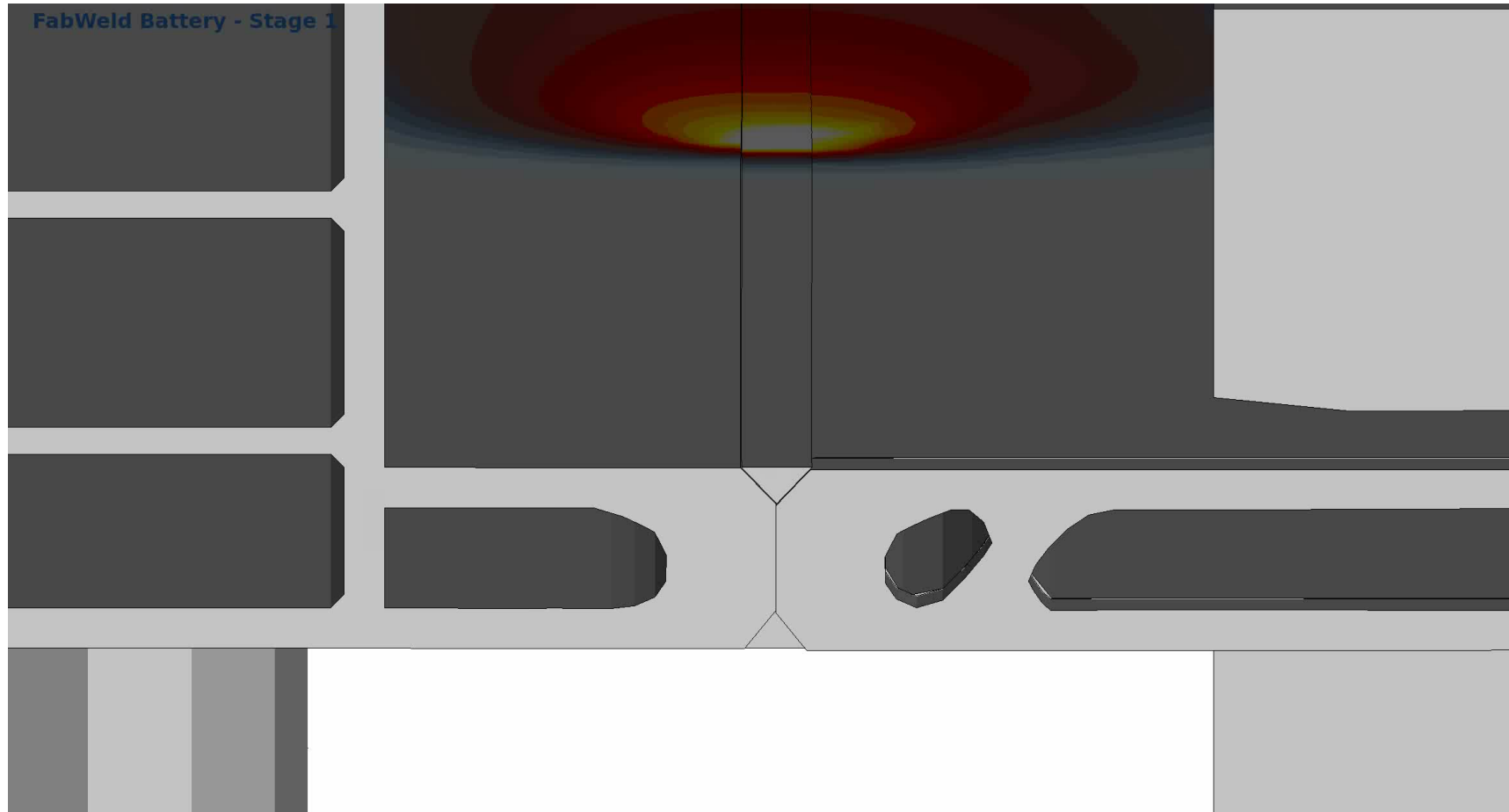
- manufacturing process of the components
- welding distortions of subassembly

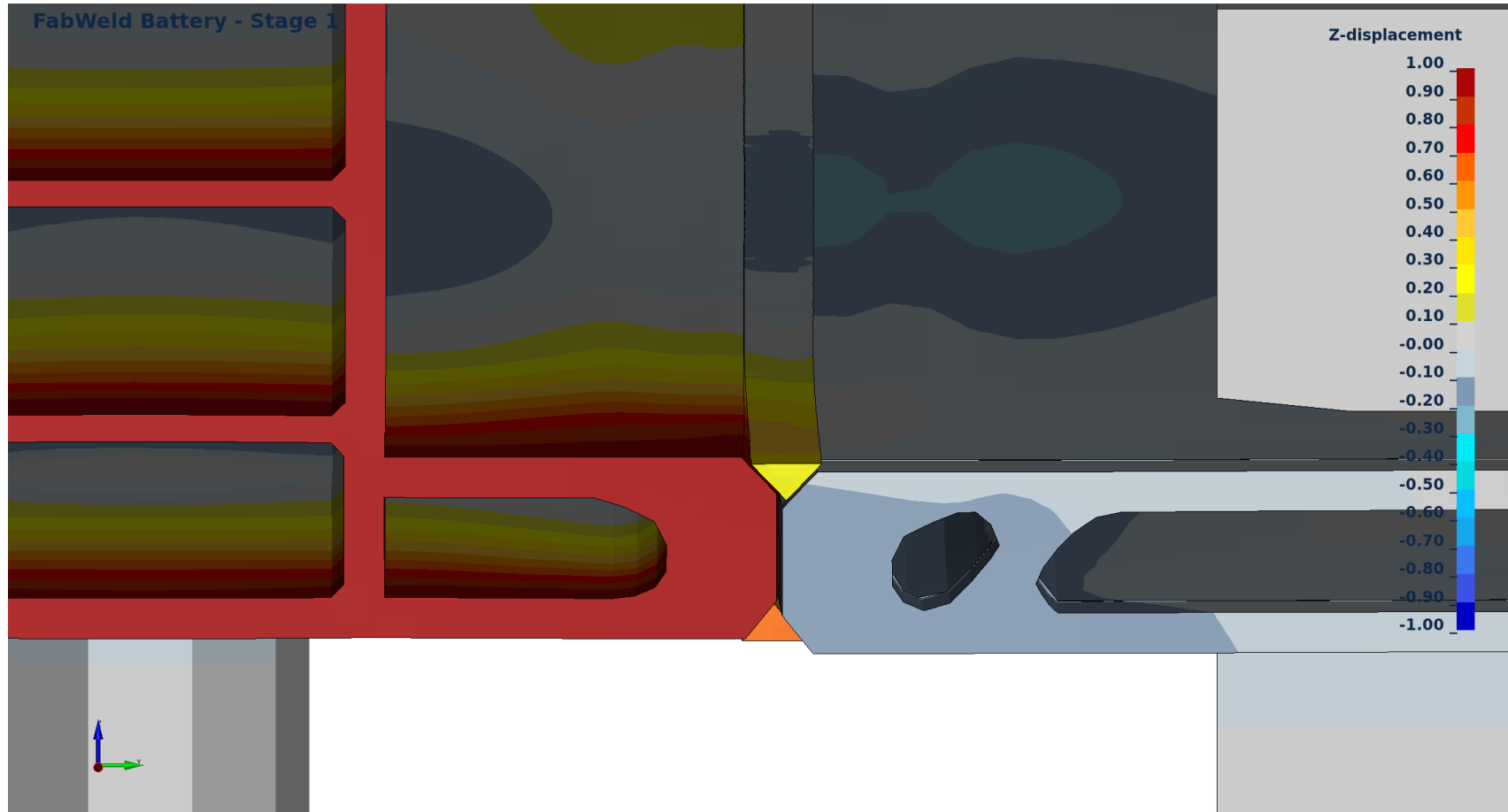
may lead to issues by non matching components.

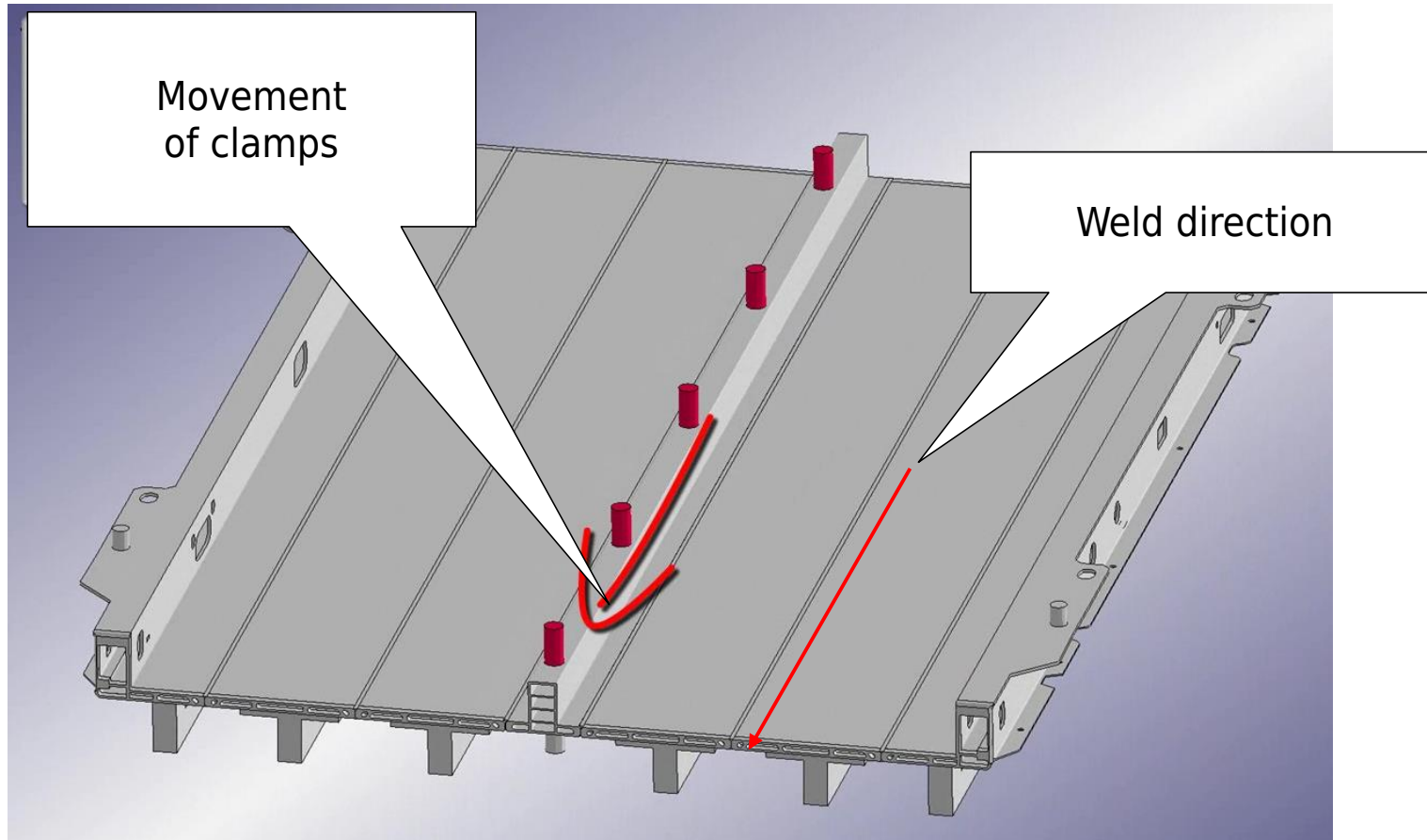
Assembly-simulation helps to predict this.

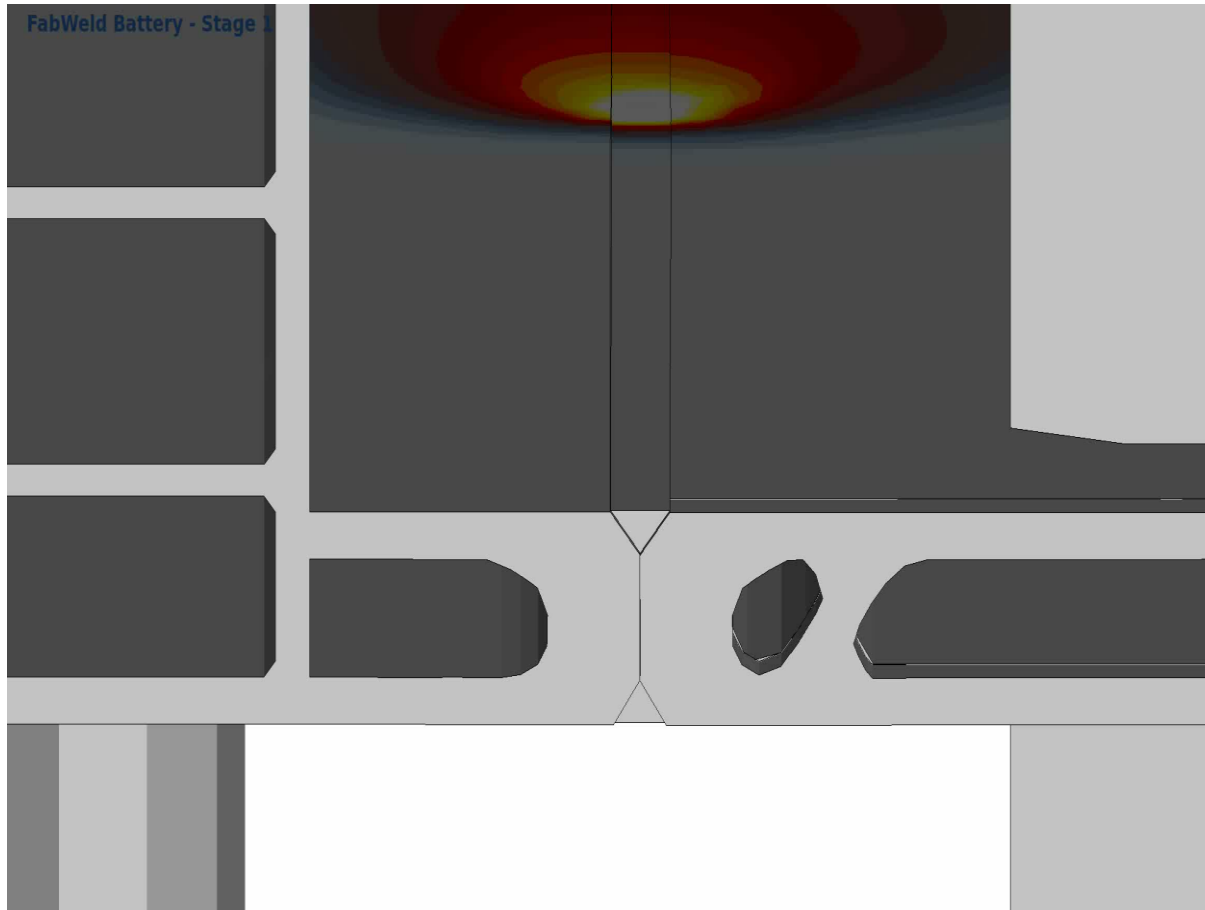


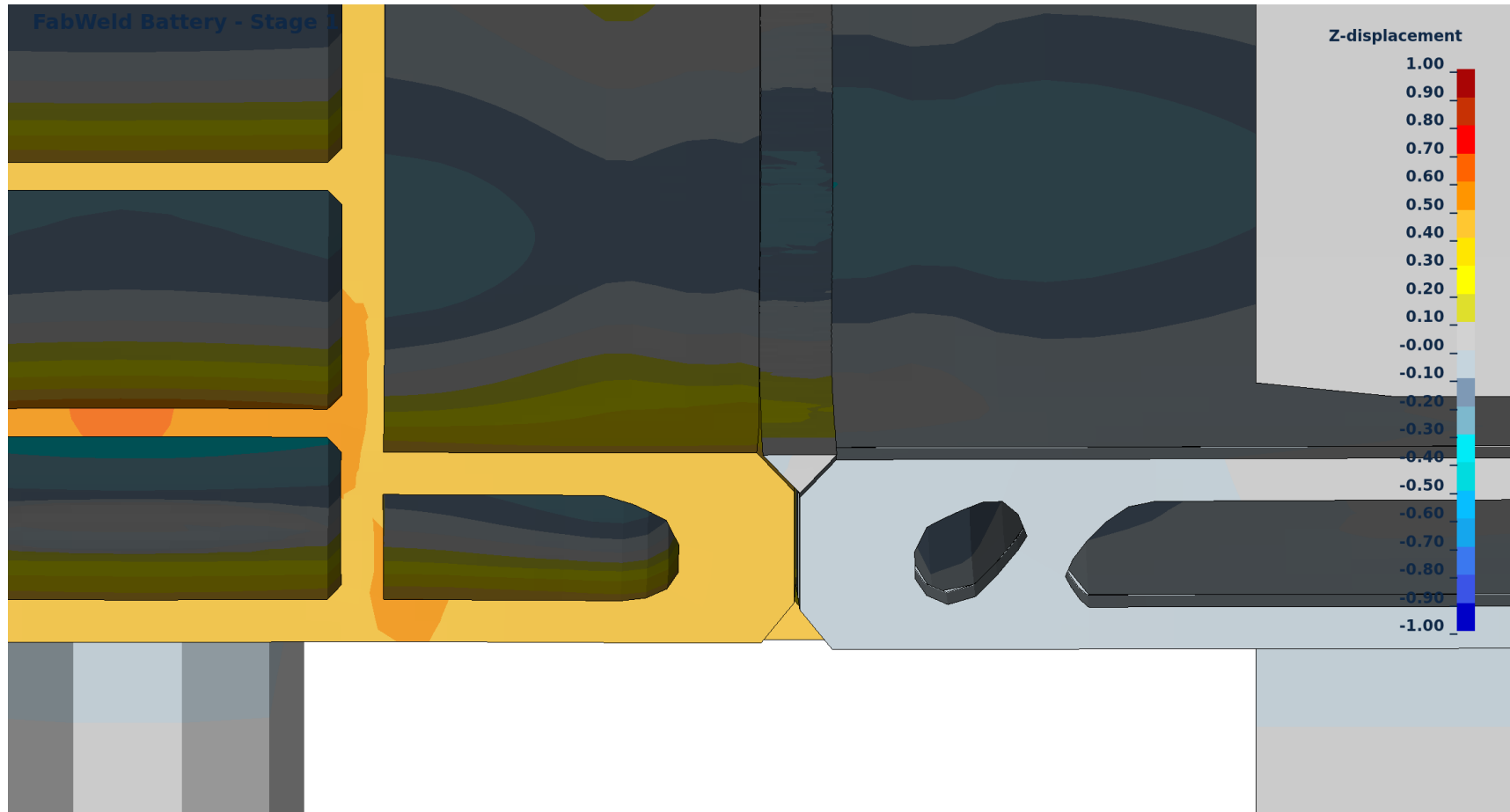
FabWeld Battery - Stage 1

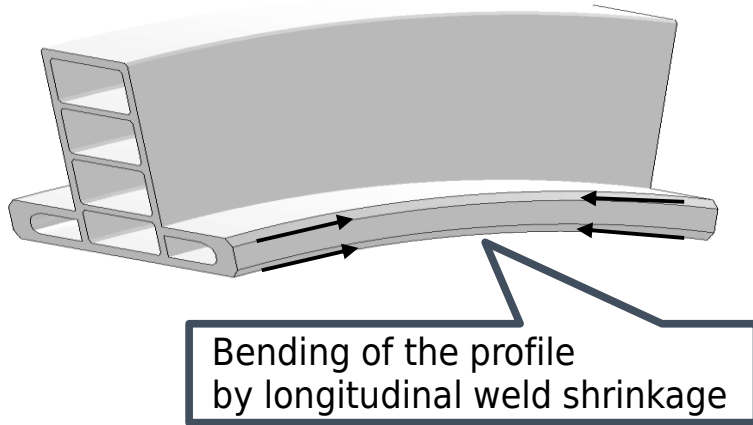






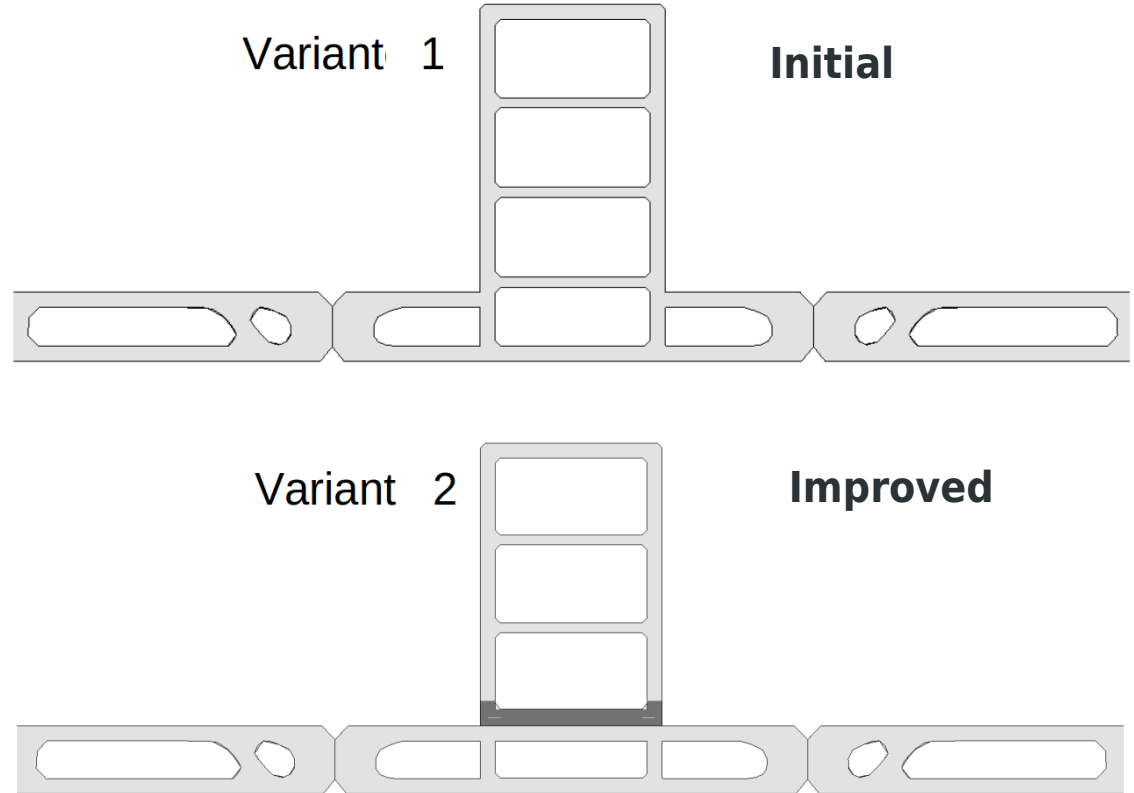




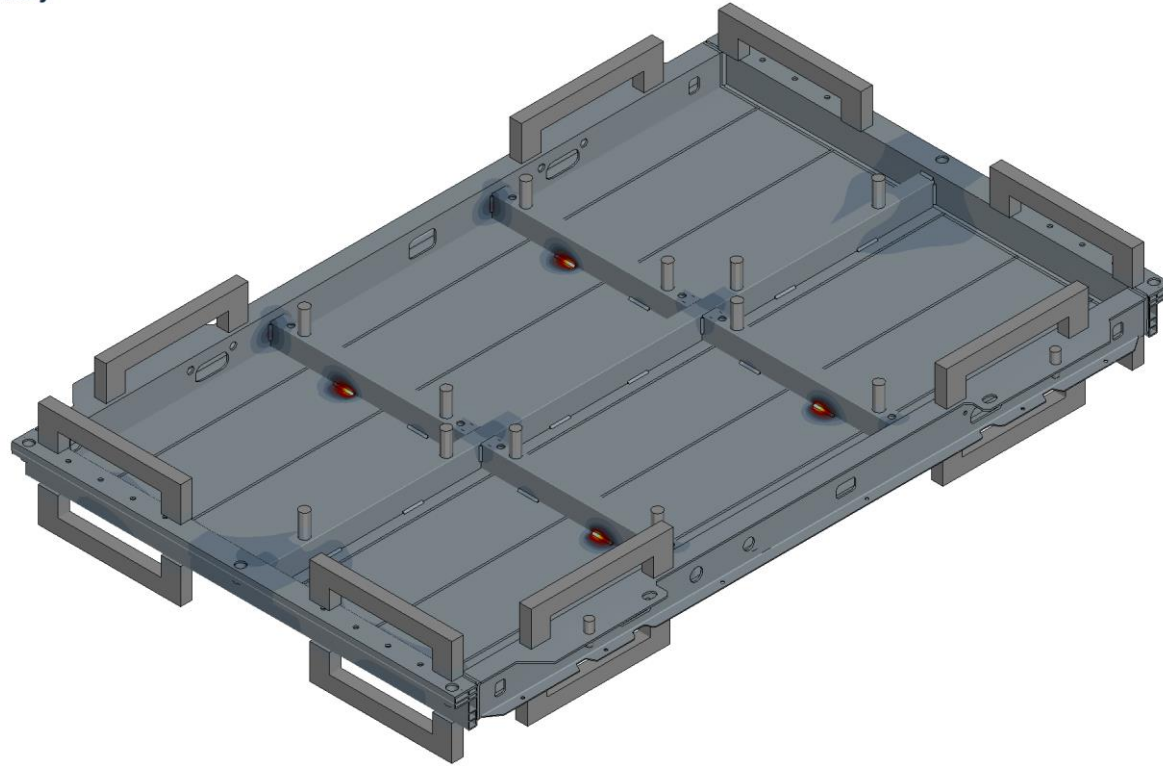


Split the middle profile

- symmetric welds in GEO 1 only
- longitudinal crossmember in GEO 3

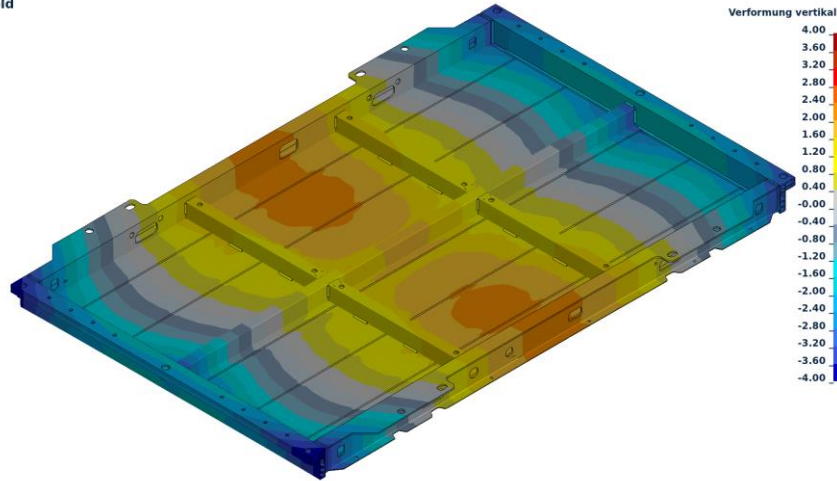


FabWeld Battery



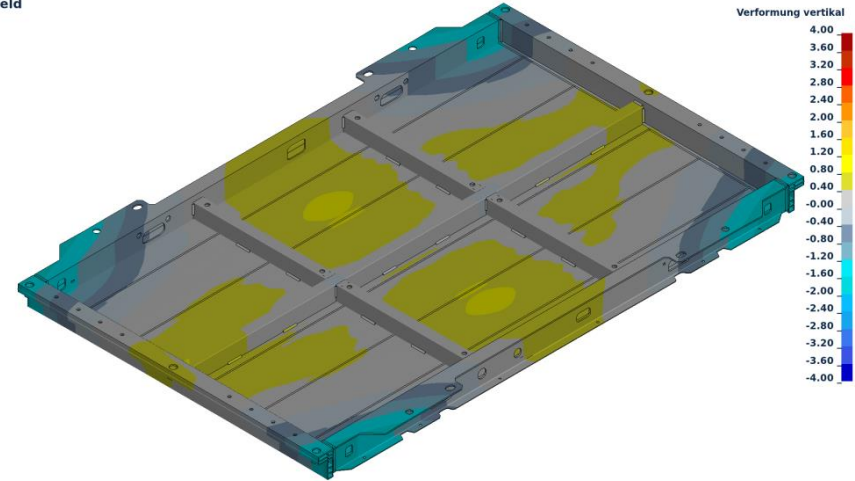
Initial

FabWeld



Improved

FabWeld



Example - Laser Welded Roof

Purpose of the Analysis:

Analyse existing process

Understanding the deformation behaviour

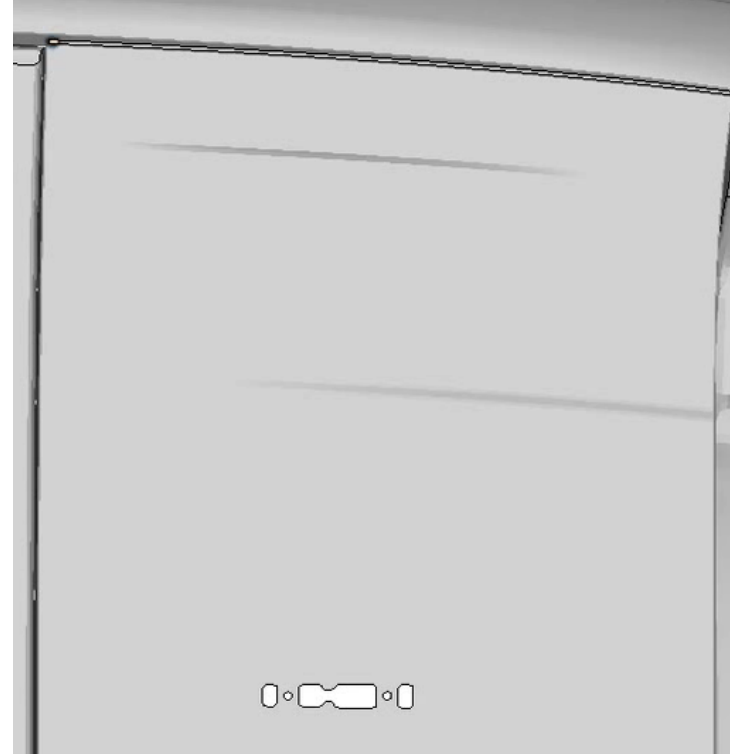
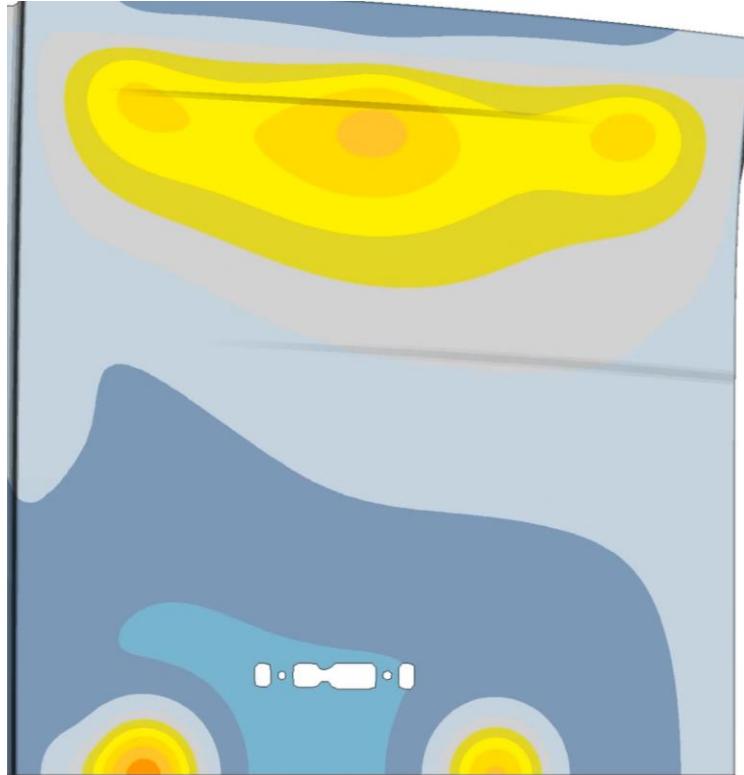
Check sensitivity

- tools
- welding process
- gaps
- imperfect single parts

Improvements

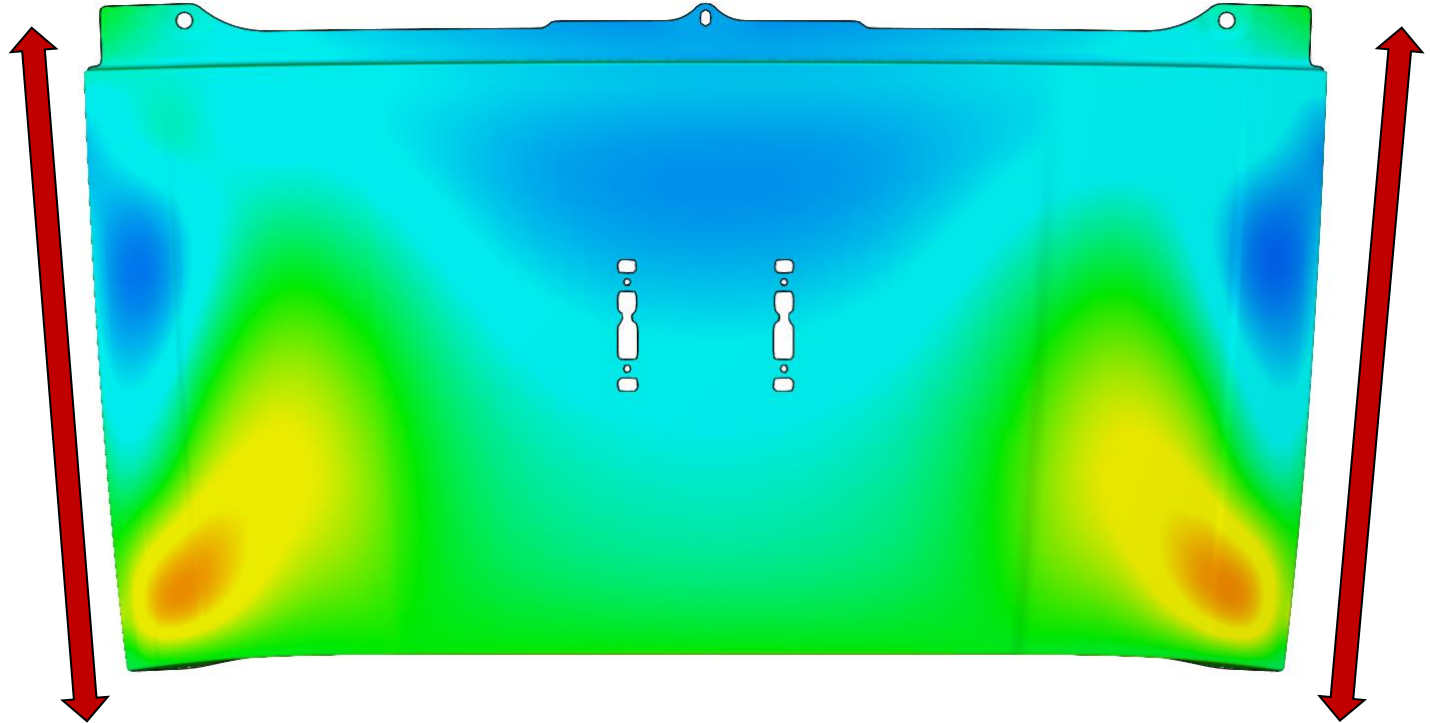


Distortion During Welding

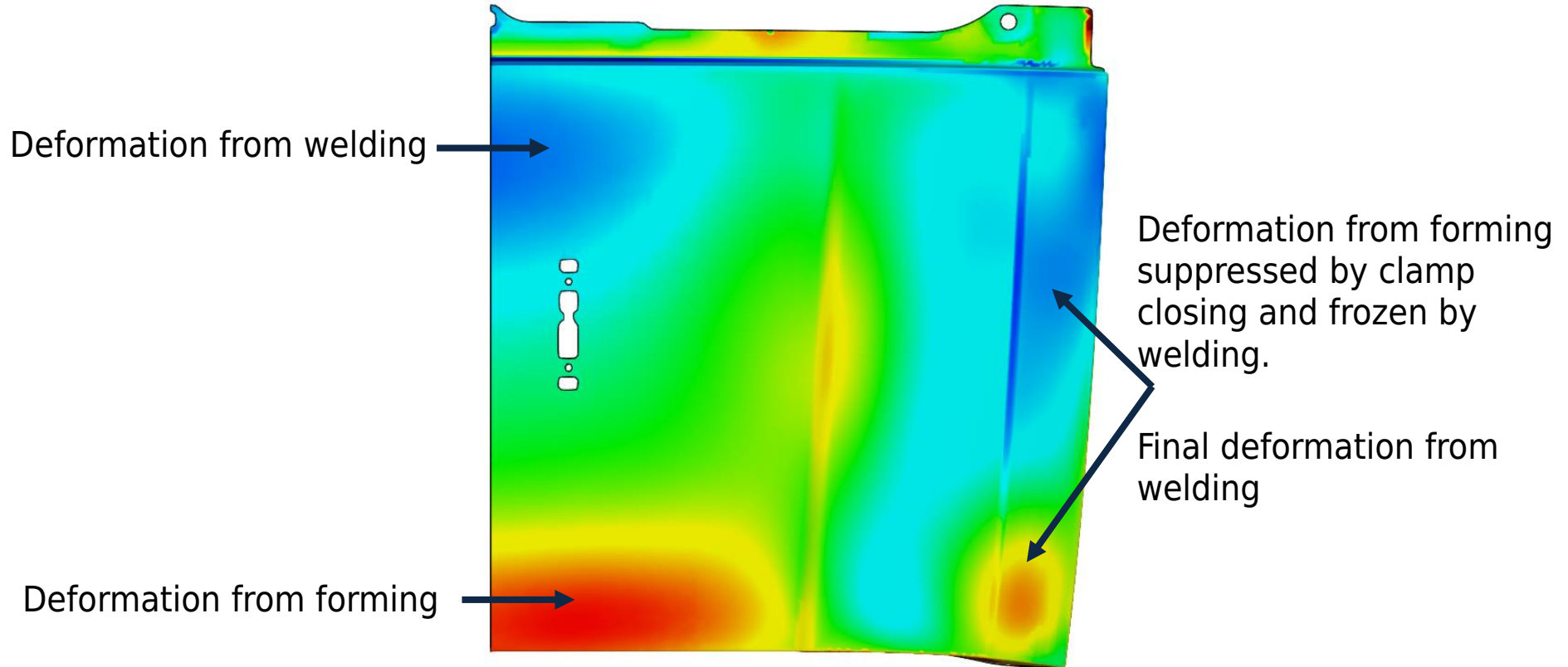


Out of plane deformation

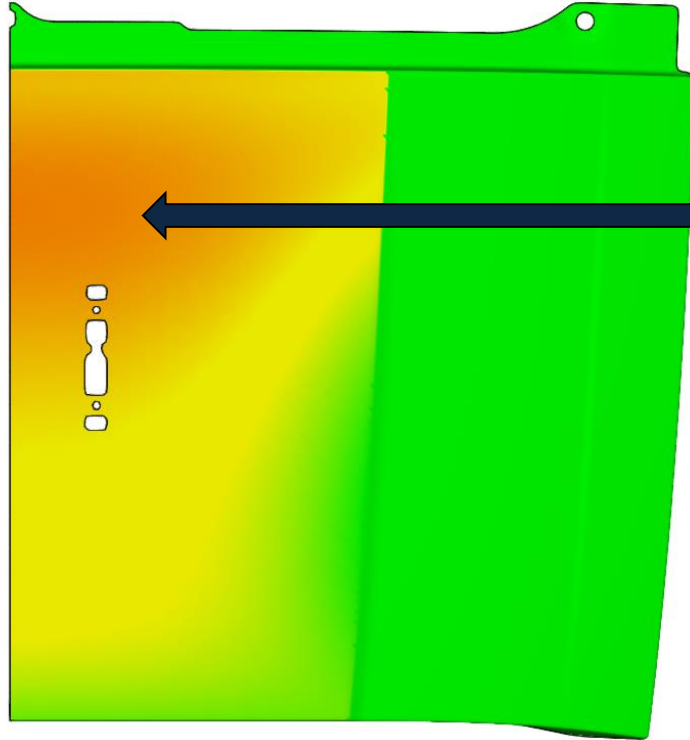
- caused by compression in the weld area,
- Similar to buckling effects
- Buckling pattern depend on the geometry
- The results of the sensitivity analysis show that the general deformation patterns remain unchanged



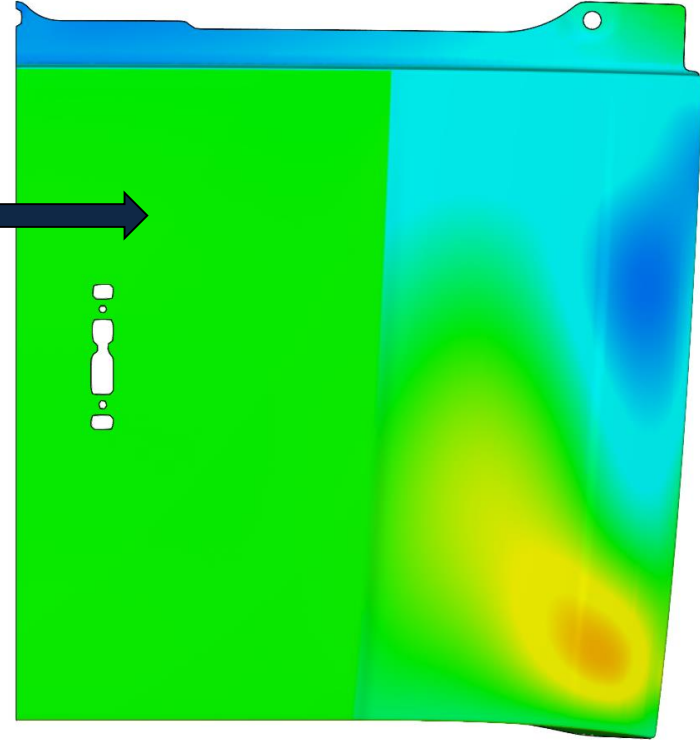
Assembly simulation with imperfect single part with geometrical deviation from forming process



Single part with
partiell inverted deformation from welding



results to zero displacement
after assembly, welding and complete cooling.





Conclusion

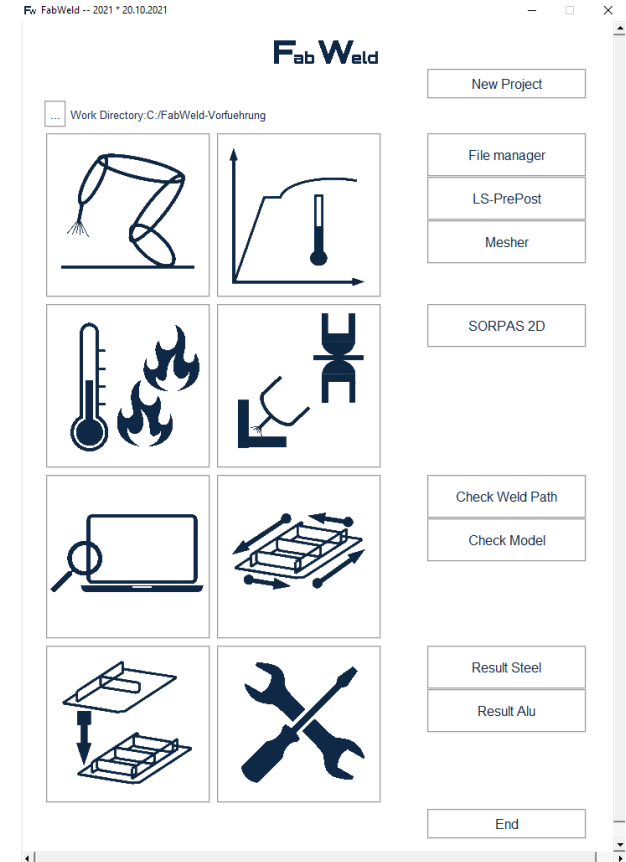
Welding simulation provides exact prediction of deformation.

Assembly simulation considers all technical boundaries in the manufacturing lines.

Assembly simulation provides:

- proof of concept – check tolerances
- detection of assembly issues
- analyse of improvements

in advance





Analyse your process

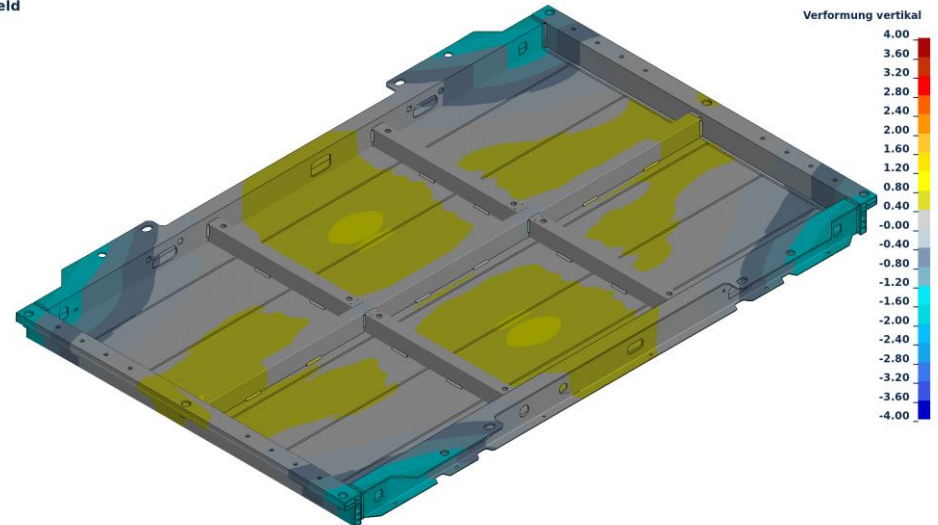
Understand distortion behaviour

Sensitivity Analysis - discover leading issues

Improvement

- *Design your manufacturing line right first time*
- *Improve your production*
- *Save many try out loops*
- *Save time to market*
- *Understand your manufacturing*
- *Avoid issues and sudden problems*
- *Avoid defective goods*

FabWeld



FabWeld

Thank you
very much

