TAILORED PROPERTIES, A BLACK BOX?

CORRELATION AND VALIDATION BETWEEN NUMERICAL ANALYSIS AND HARDWARE TESTING

Paul Deller, GEDIA Automotive

GREAT DESIGNS IN STEEL™

Table of Contents

Company Profile

GDIS

Automotive supplier

Stamping and forming technology

9 Production sites

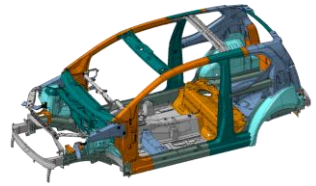
Worldwide

Employees worldwide

4.800

GEDIA

Product portfolio



Car body and structural components

Development center

Germany - Attendorn

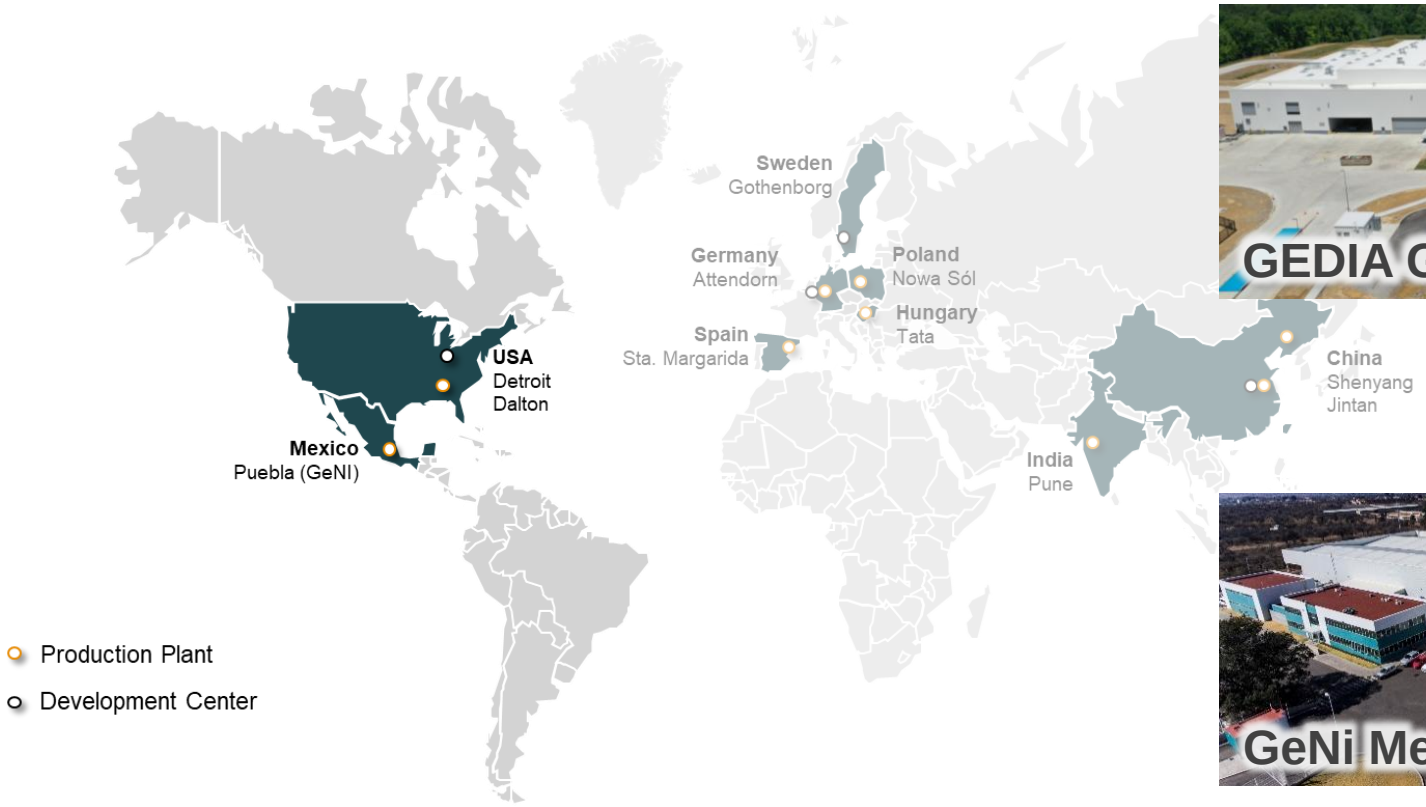
Special features in press hardening

Multilayer chamber furnace with TemperBox®

AP&T

Company Profile

NA Locations



Technologies

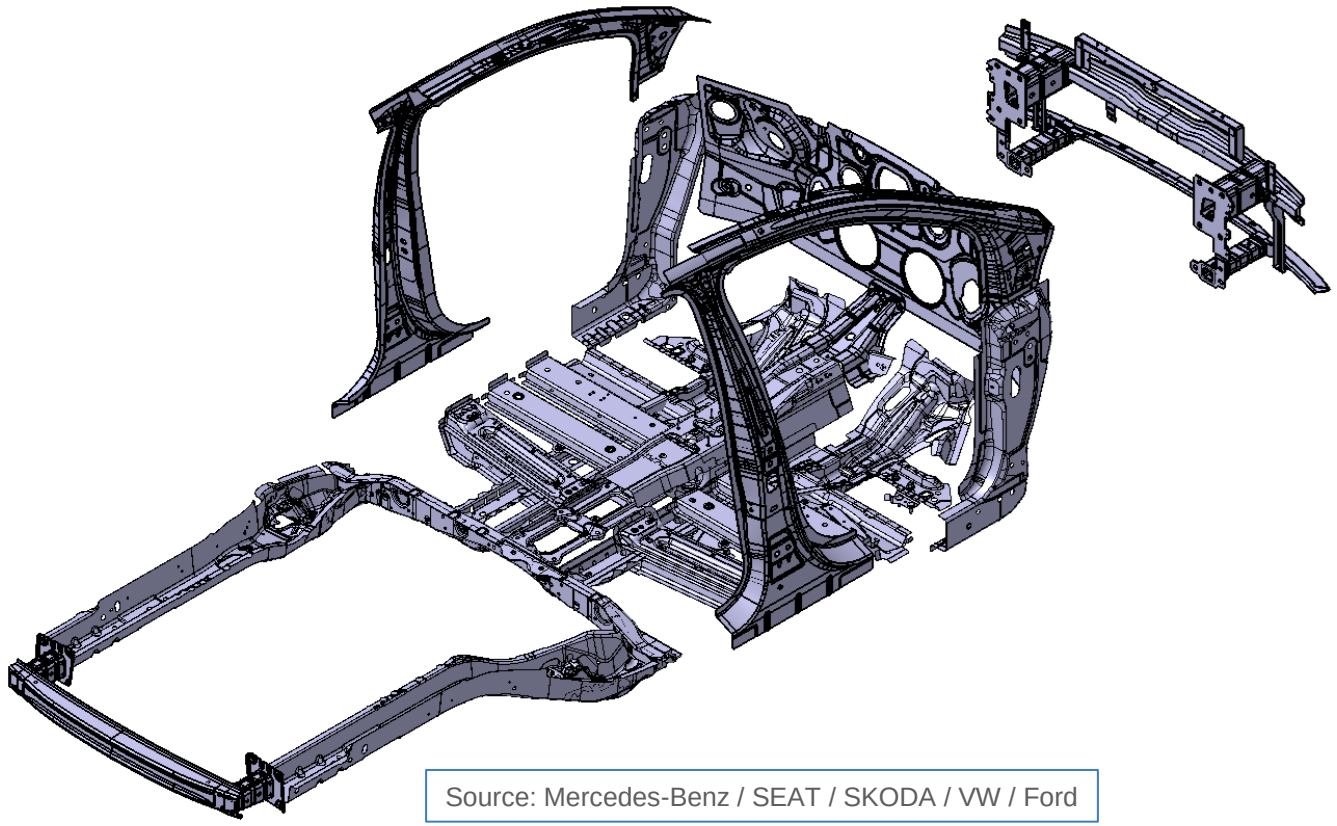
- Hot forming incl. TemperBox®
- 3D laser cutting
- Spot welding
- Projection welding
- Gluing

Technologies

- Cold forming | transfer presses
- Spot welding
- Projection welding
- Arc welding

Company Profile

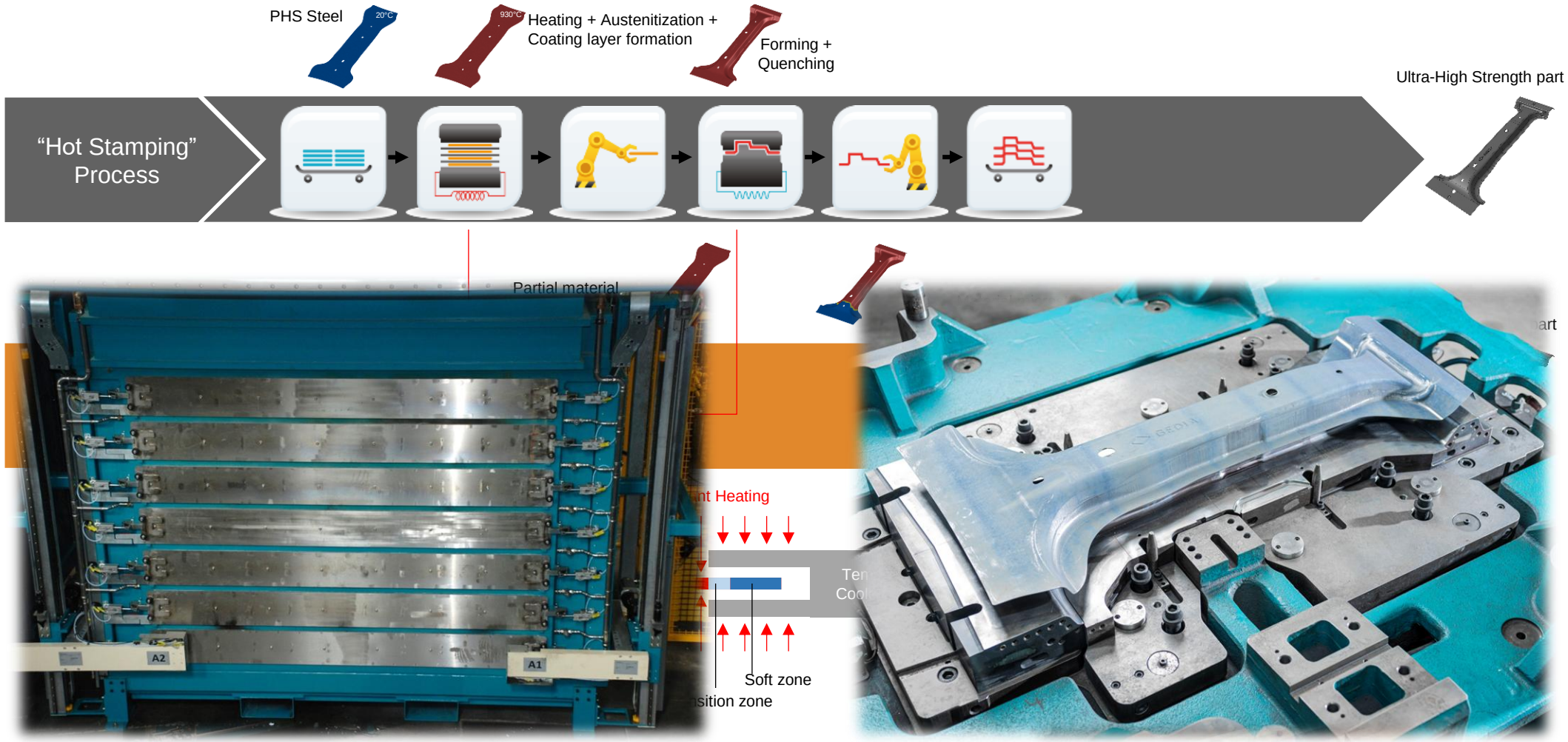
Products – Examples of typical applications



Source: Mercedes-Benz / SEAT / SKODA / VW / Ford

TemperBox®

Process description



TemperBox®

Please see our previous GDIS presentation,
“Tailored Properties in Advanced Hot Stamped BIW Applications Using the TemperBox® Technology”,
for more details about the TemperBox ® process.

Link:

Tailored Properties in Advanced Hot Stamped BIW Applications Using the TemperBox® Technology

Options for Safety Parts

TemperBox® Technology gives design teams incredible design flexibility:

- Several ductile areas within one part possible
- Process works with multiple part blank styles

Design teams need reliable tools to develop parts which put the advantages of TemperBox® Technology to use.

- GEDIA has developed CAE simulation methods to meet the needs of design teams at two distinct project phases:
  - The Concept Stage Method
  - The High Accuracy Method

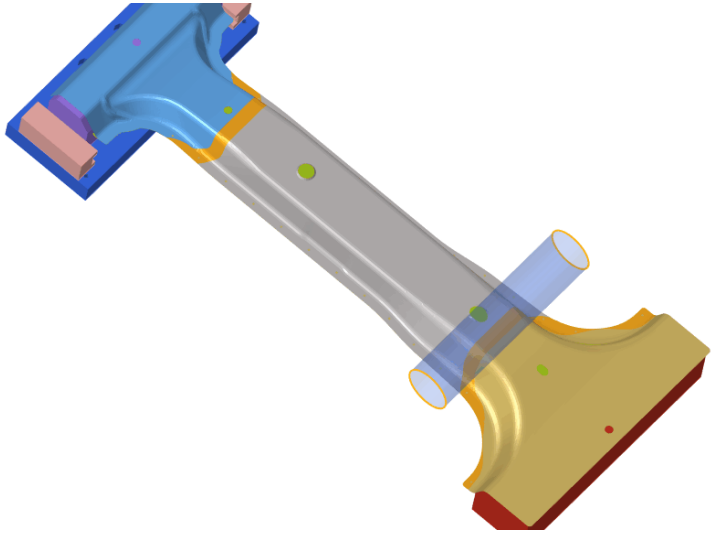
Hardware Test

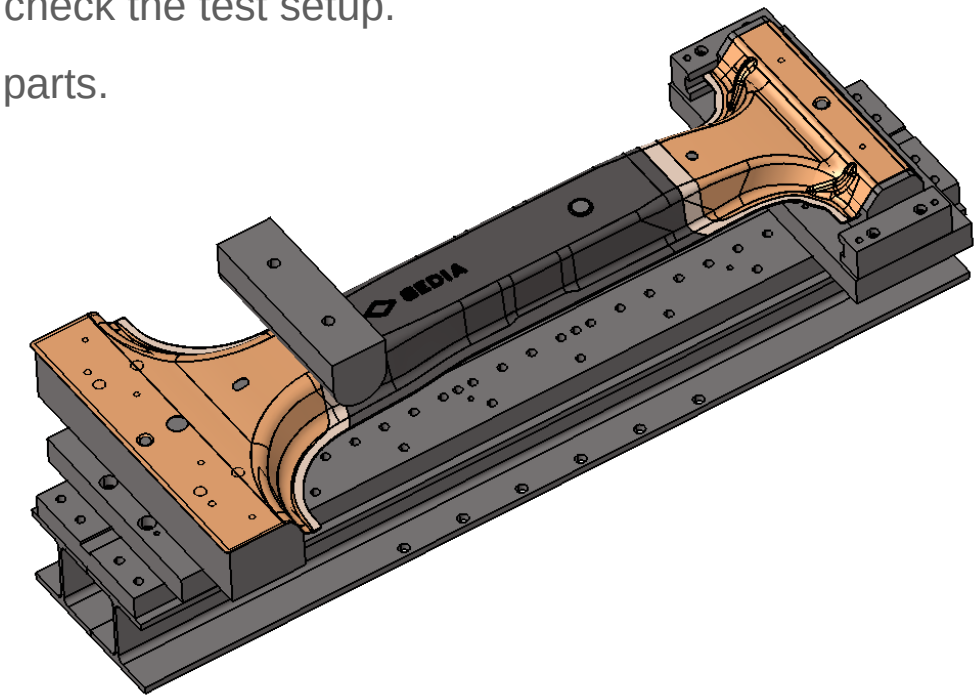
CAE Methods Proven with Physical Testing

Design teams need to proven methods to develop their products.

GEDIA has performed testing to confirm both the Concept Stage and High Accuracy Methods.

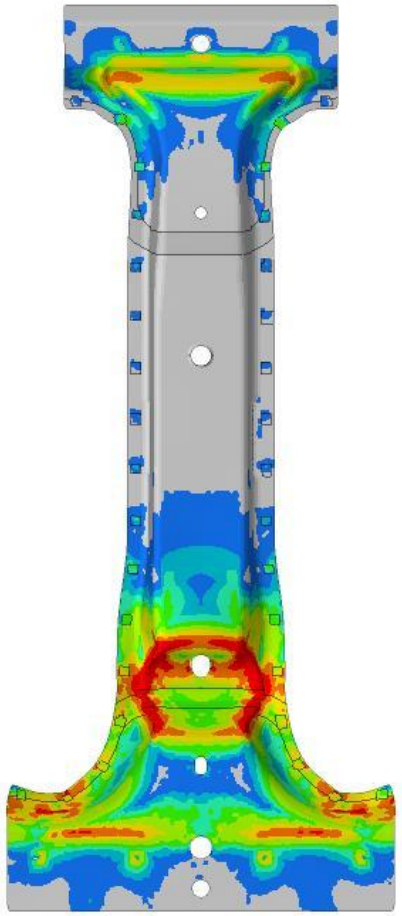
- A 3-Point Bending test was used to correlate and validate these methods.
- The TemperBox® transition zone was the focus of the physical testing.
    - The ram was centered on the transition zone.
- Single material property hot formed parts were used as control samples to check the test setup.
    - The ram was centered at the same position used for the TemperBox® parts.

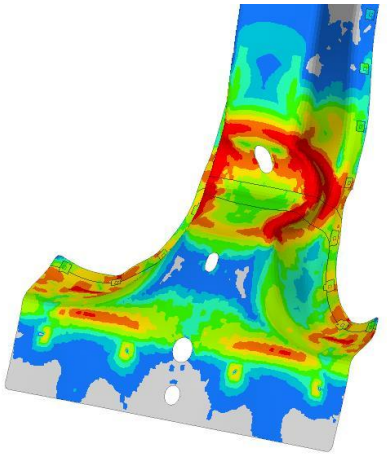




Hardware Test

Hardware Test vs Simulation: Hot Formed Parts

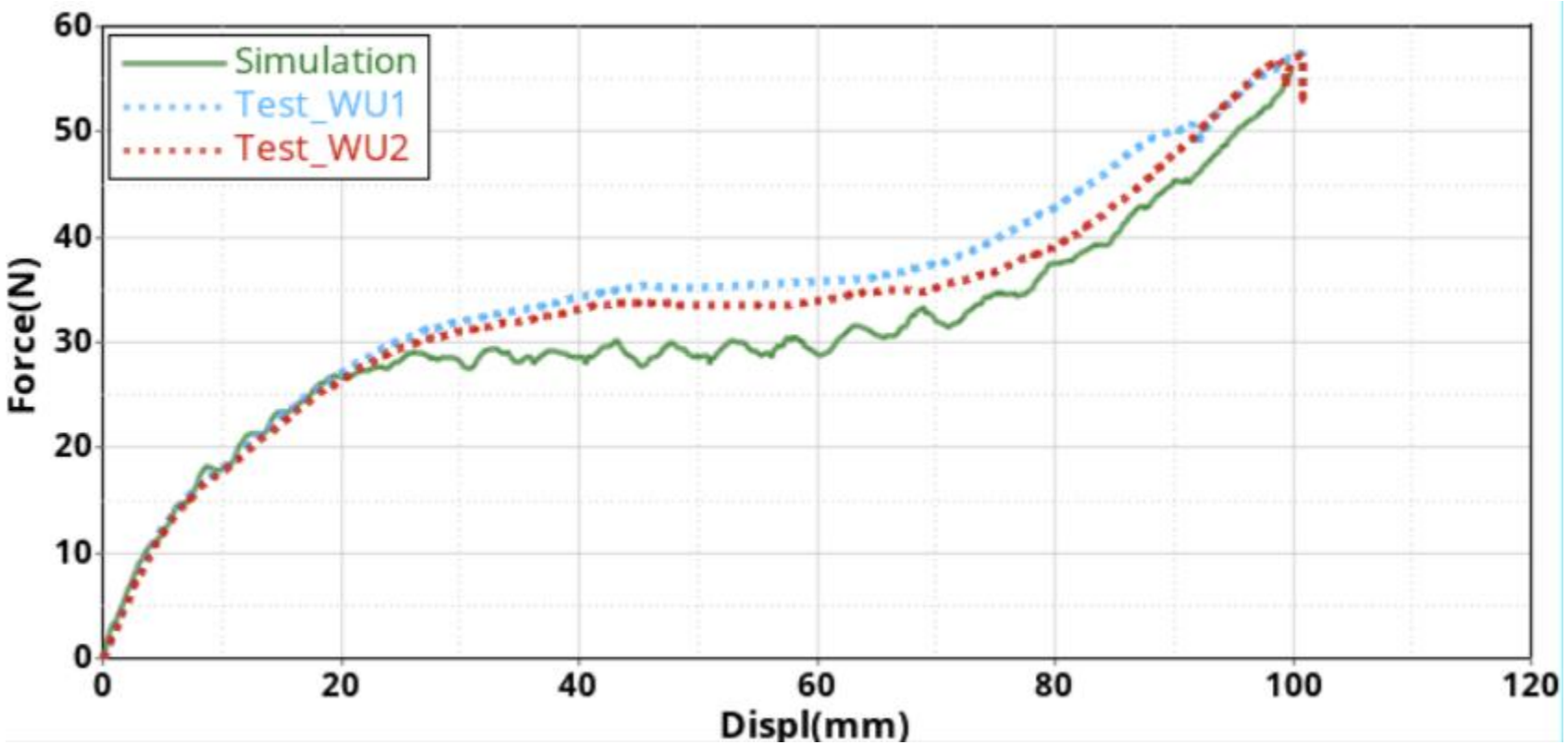




As expected, the CAE results of the single property hot stamped B-pillar look very similar to the tested part.

Hardware Test

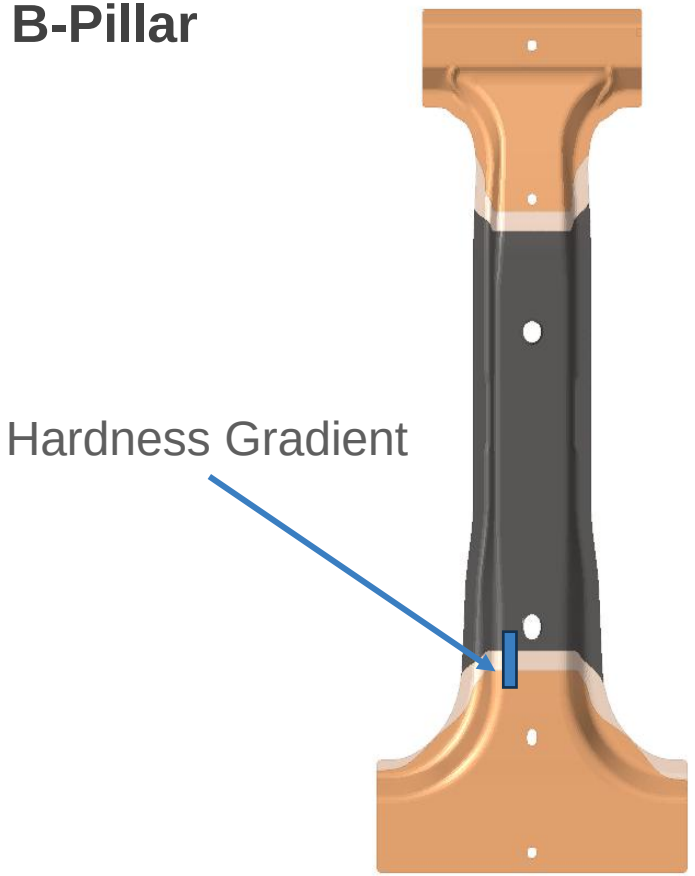
Curve Comparison: Hot-Formed Parts



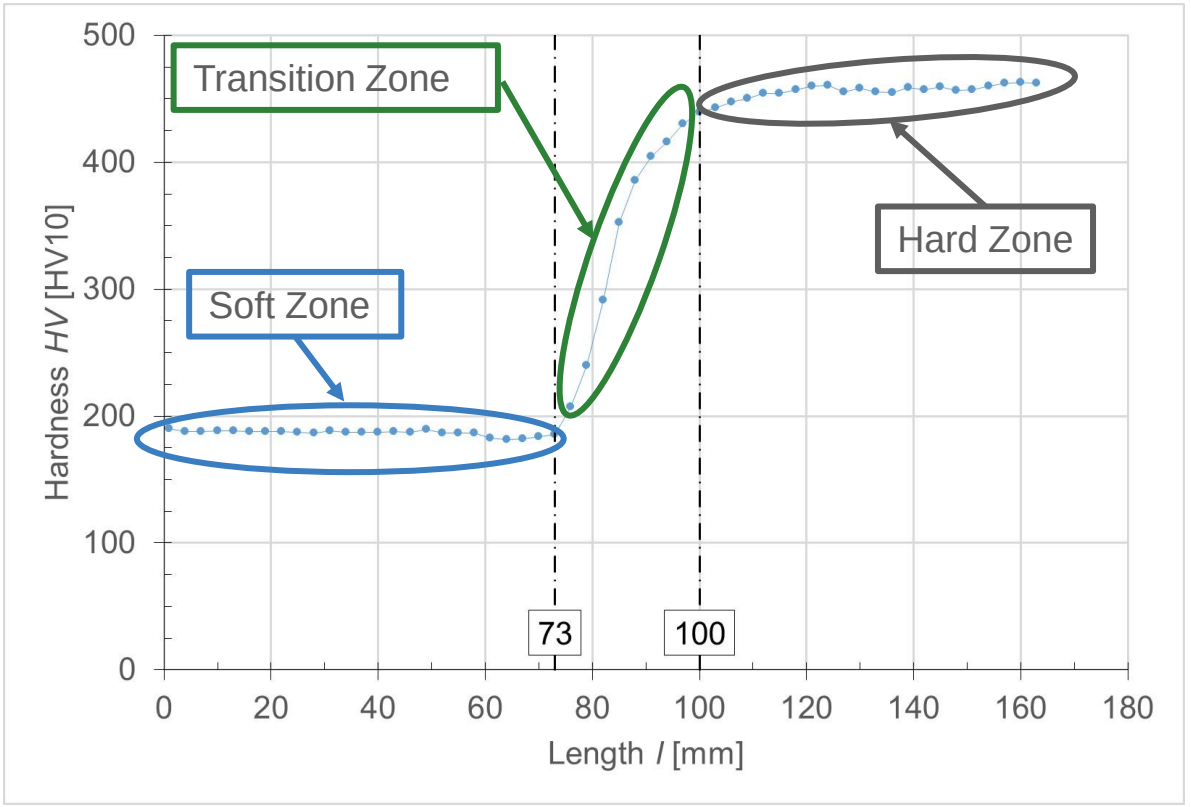
The CAE results of the single property hot stamped B-pillar correlate to the tested part data.

Hardware Test

B-Pillar



Hardness Gradient for B-Pillar



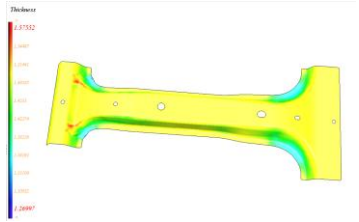
- The TemperBox® transition zone was the focus of the physical testing.
  - Understanding material hardness in the transition zone is critical to simulating component performance.
  - Material hardness data can be collected from physical samples or created from process simulation.

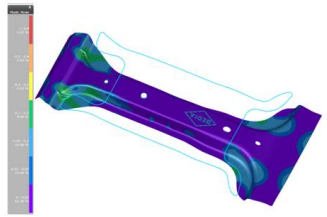
Numerical Analysis: High Accuracy Method

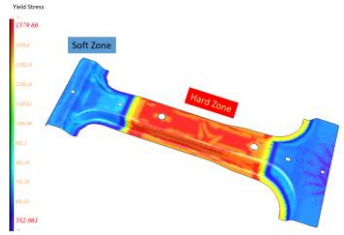
Mechanical Property Mapping

The High Accuracy Method assigns detailed definitions of material properties and failure criteria to each element in the product FE model individually.

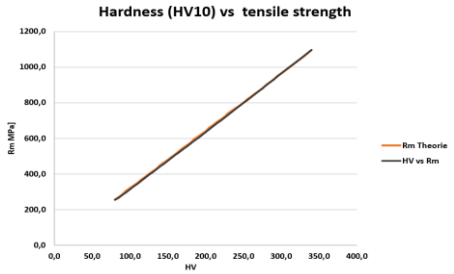
- This method provides high accuracy models to help teams assess readiness for physical testing.
- Process simulation provides input data maps for thickness, plastic strain, and hardness

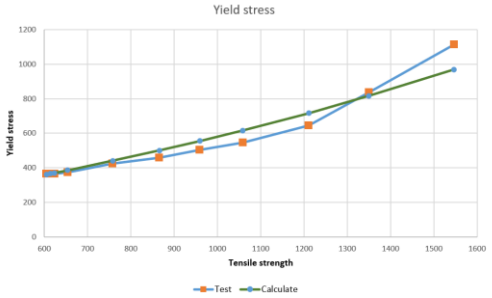


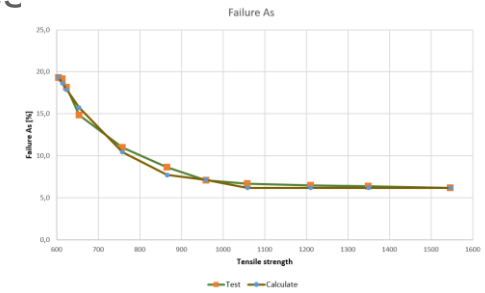




- Hardness data is used to generate tensile, yield, and failure values



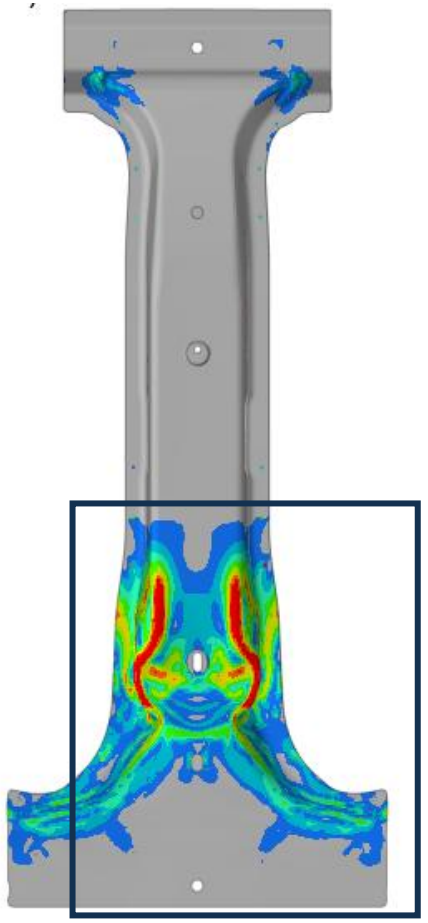


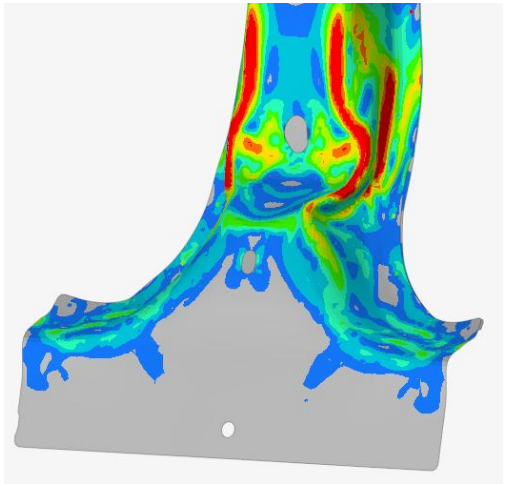


Hardness → **Tensile Stress** → **Yield Stress** → **Failure**

Numerical analysis: High Accuracy Method

Hardware Test vs. Simulation

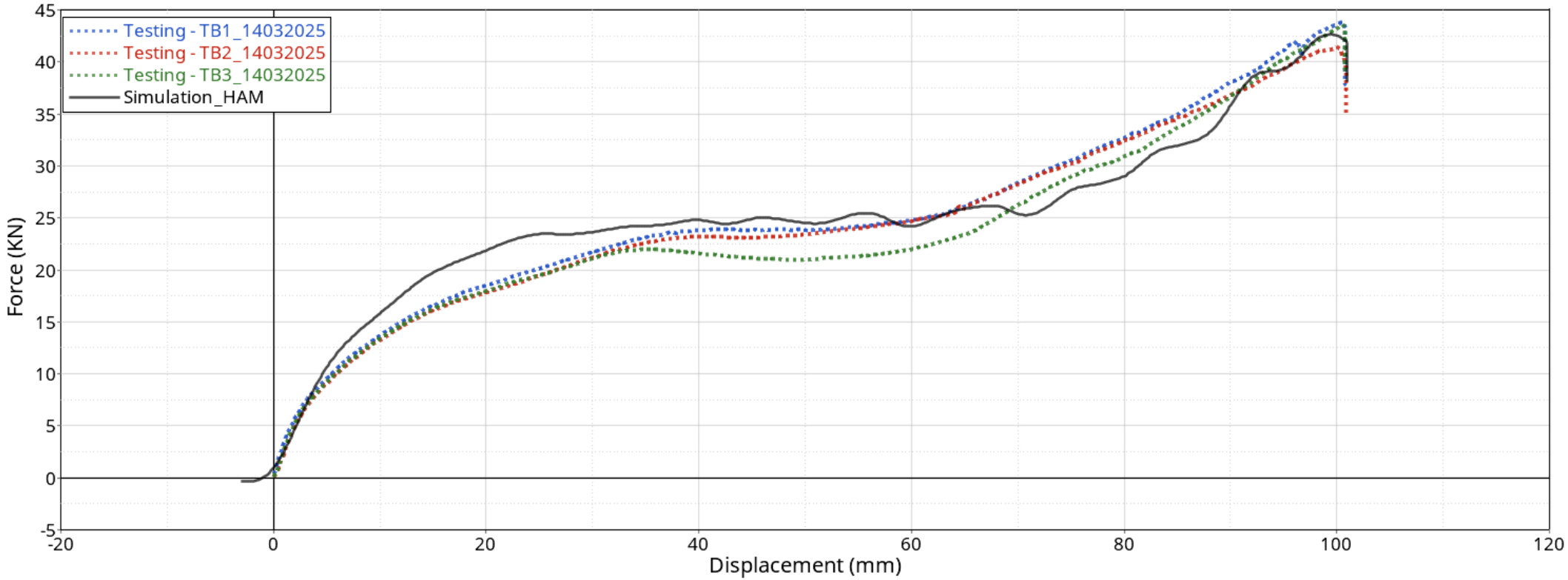




The results of the High Accuracy method model of the TemperBox® B-pillar look similar to the tested part.

Numerical analysis: High Accuracy Method

Curve Comparison



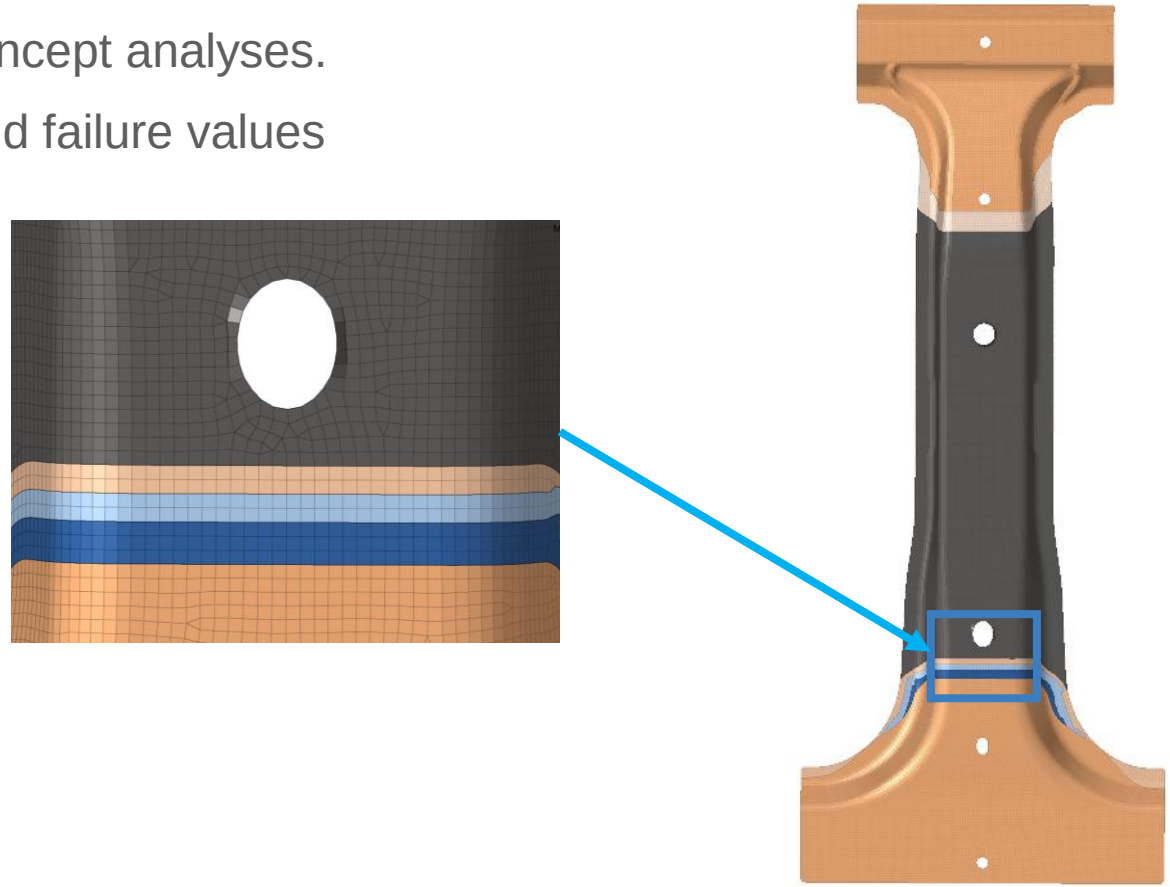
The results of the High Accuracy method model of the TemperBox® B-pillar correlate to the tested part results.

Numerical analysis: Concept Stage Method

Initial Project Phase Models

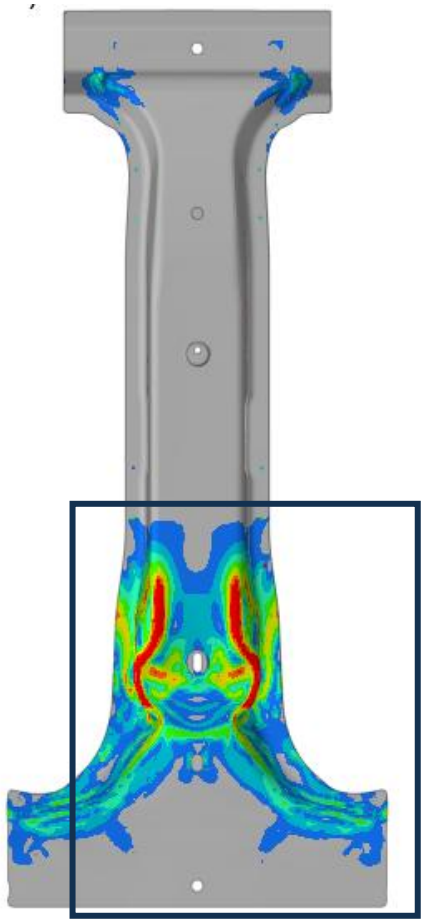
The Concept Stage Method can be used to define different material properties for hard, soft and transition zones based on hardness values in defined areas.

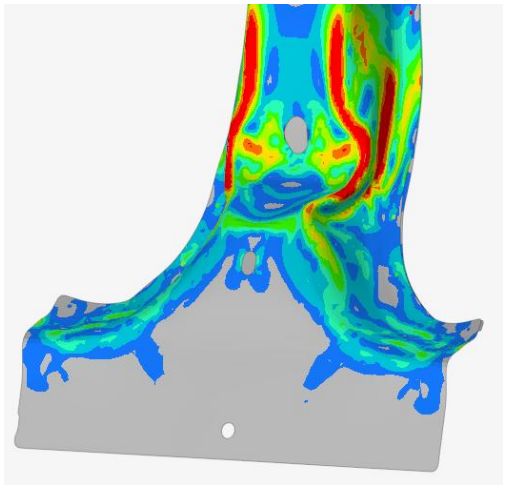
- This method provides quicker iteration of design concept analyses.
- Hardness data is used to generate tensile, yield, and failure values
- The transition zone is split into defined zones
  - Element Material Properties are set by zone.
  - Standard Element size ≈ 2 - 4mm
  - Total Width of transition zone ≈ 30mm



Numerical analysis: Concept Stage Method

Hardware Test vs. Simulation





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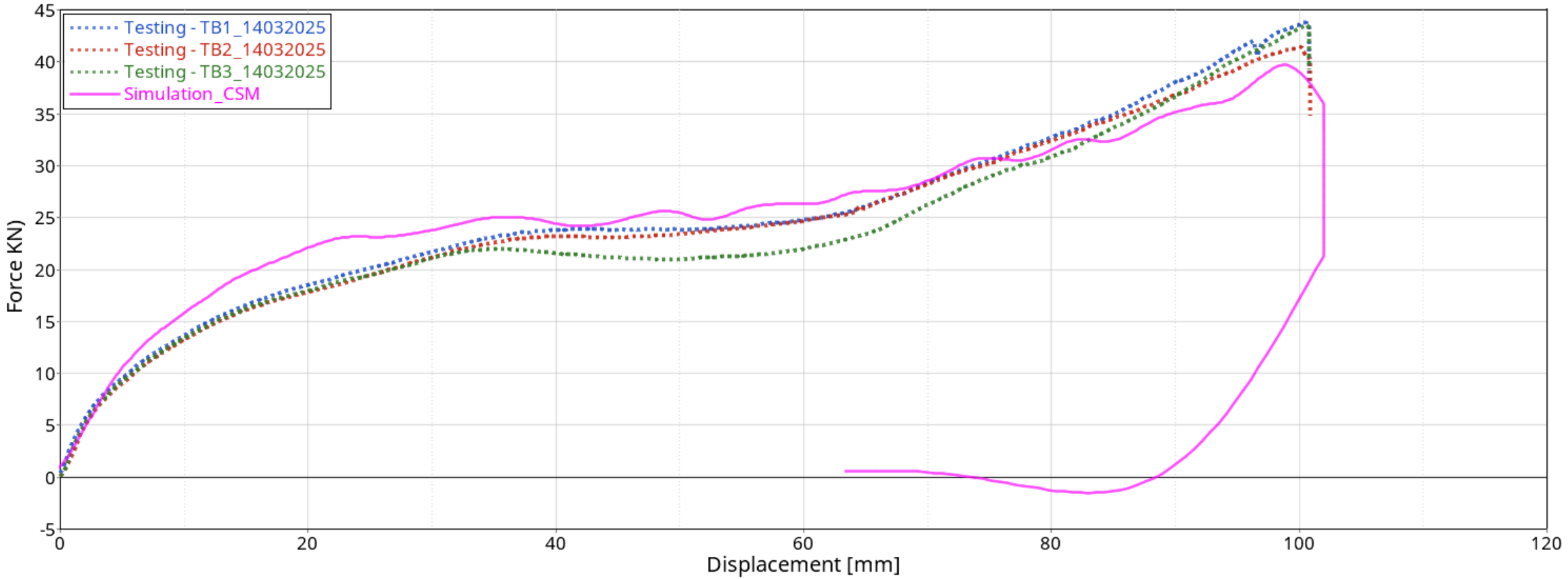
Numerical analysis: Concept Stage Method

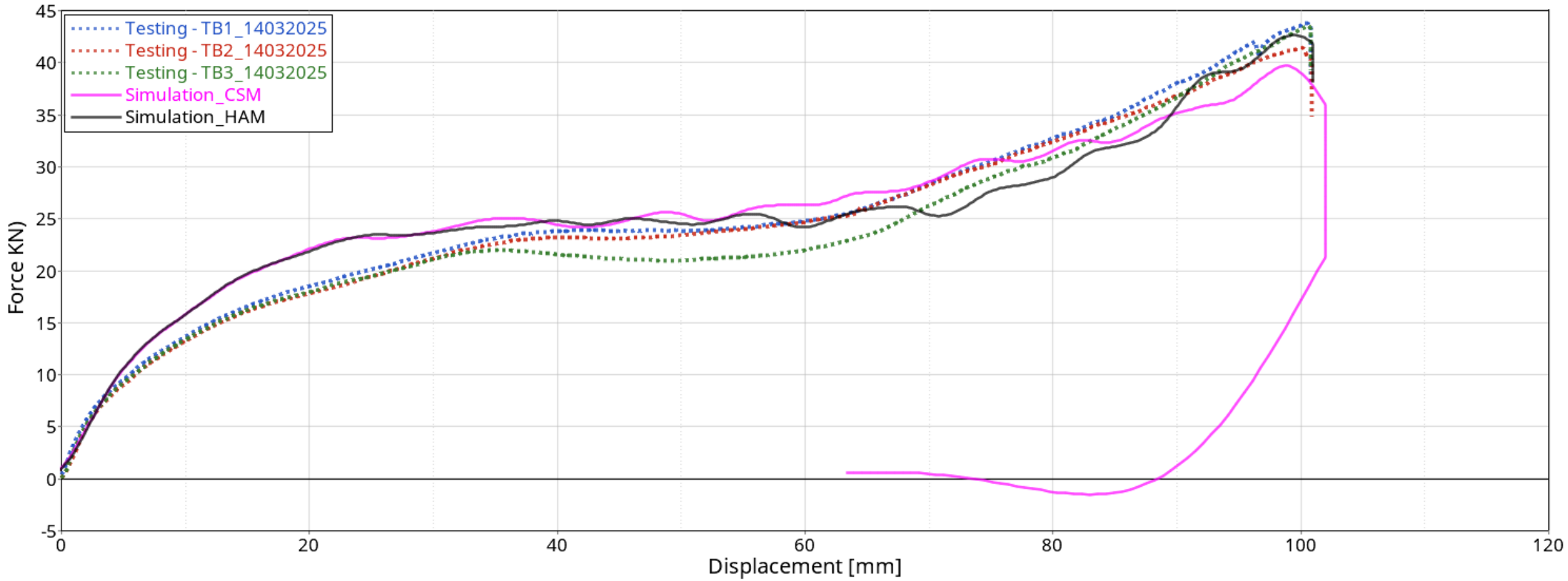
Curve Comparison



The results of the Concept Stage method model of the TemperBox® B-pillar correlate to the tested part results.

Conclusion

High Accuracy Method vs. Concept Stage Method

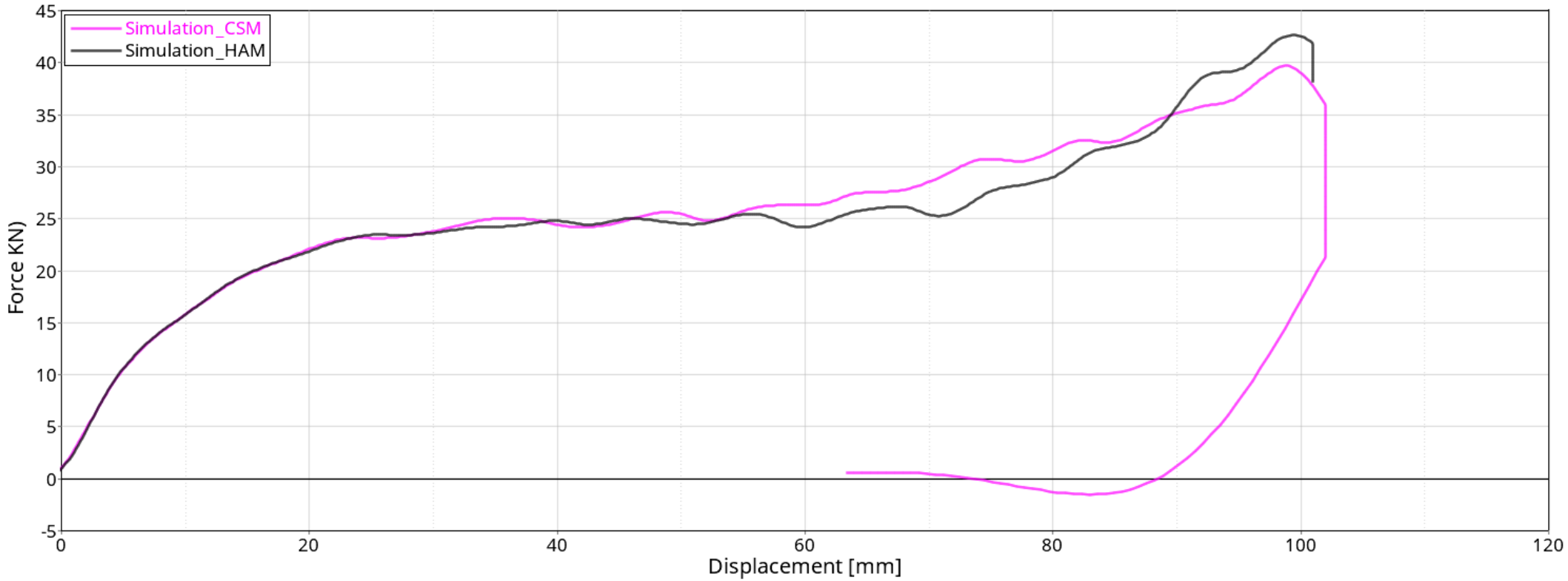


Putting all the TemperBox® B-pillar graphs together shows us the relative accuracy of the analysis methods.

- The High Accuracy Method is within 90-95% of the physical test result
- The Concept Stage Method is within 85-90% of the physical test result

Conclusion

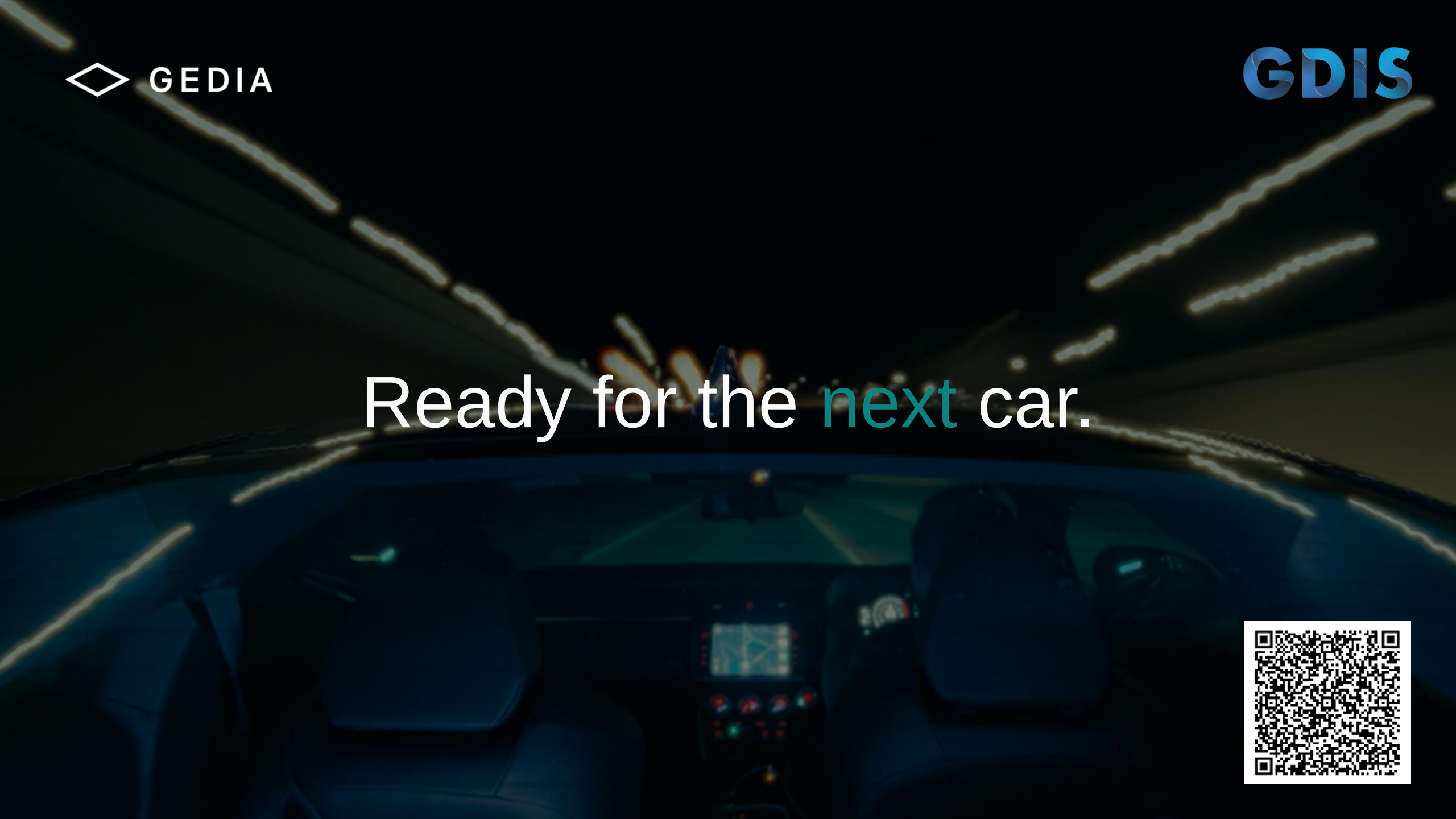
High Accuracy Method vs. Concept Stage Method



Removing the physical test curves from the TemperBox® B-pillar graphs lets us see similarities and differences between the two analysis methods.

Conclusion

- TemperBox® technology, developed by GEDIA, enables hot stamped component production integrating varied mechanical properties within a single part.
  - The technology can be used to combine all common grades of press hardened materials, strengths from 500 to 2000 MPa, with targeted soft zones; offering vehicle teams significant design flexibility.
- GEDIA has developed two distinct CAE simulation methods to meet the needs of design teams at two different design project phases.
  - In early project phases, the Concept Stage Method can be used to define different material properties for hard, soft and transition zones based on hardness values in defined areas.
    - This method provides quicker iteration of design concept analyses.
  - In later phases, the High Accuracy Method assigns detailed definitions of material properties and failure criteria to each element in the FE model individually.
    - This method provides high accuracy models to help teams assess readiness for physical testing.
- Both these methods help design teams use CAE models to leverage the design flexibility of TemperBox® technology to improve vehicle performance.


GEDIA
GDIS
Ready for the next car.