GREAT DESIGNS IN STEEL

TWENTY YEARS

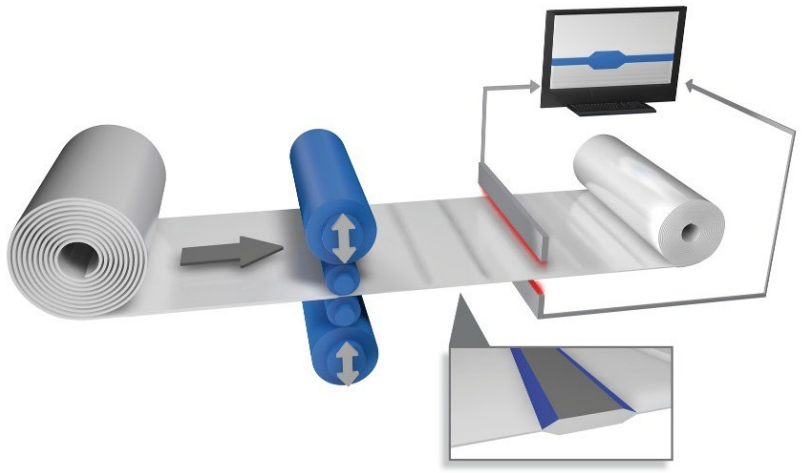
APPLICATION OF NEW COLD FORMING FLEXIBLE ROLLED AHSS

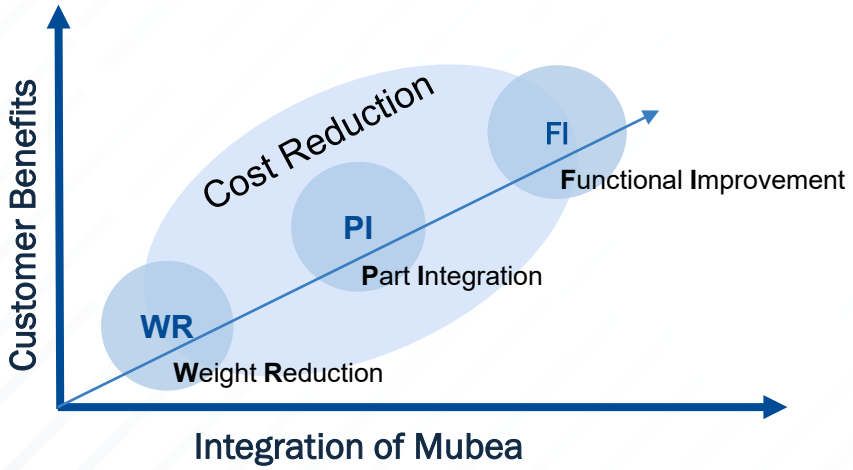
Markus Zoernack

Mubea Tailor Rolled Blanks, LLC.

FLEXIBLE ROLLING PROCESS

Flexible rolling:





Idea

- Lightweight parts with load and function-optimized material usage and improved performance

Implementation

- Flexible Cold-Rolling process
- Flat material with repeated, varying thicknesses and harmonious transition zones
  - No heat affected zone
  - No notch effect
  - No stress peaks at thickness changes
- Thickness distribution change is software driven

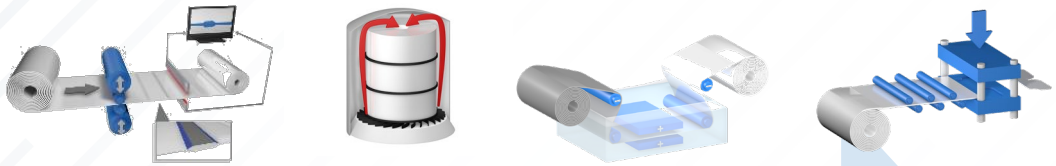
➔ **Thickness run optimization drives the cost efficiency**

Targets / Benefits

- Weight reduction
- Part integration / design simplification ➔ cost reduction
- Functional improvement (crash, manufacturing,…)

COLD FORMING VS. HOT FORMING

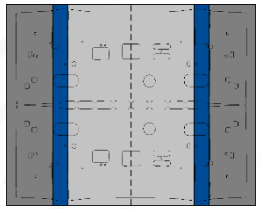
Cold Form Material



Flex Rolling → Annealing (optional) → Coating (optional) → Blanking or Forming

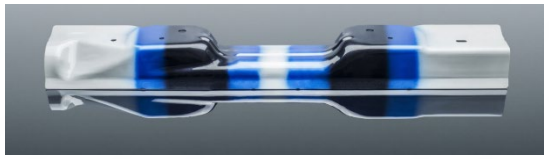
Product portfolio:

Rectangular Blanks [TRB]

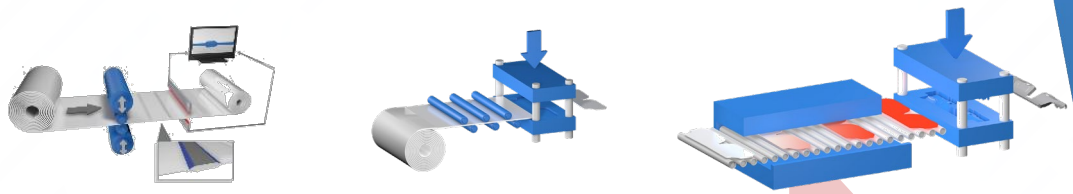


Tailor Shaped Blanks [TRS]

Cold Stampings & Assemblies [TRP-C]



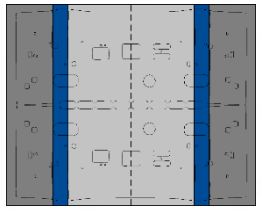
Hot Form Material



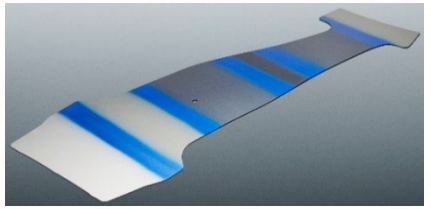
Flex Rolling → Blanking → Heating + Forming

Product portfolio:

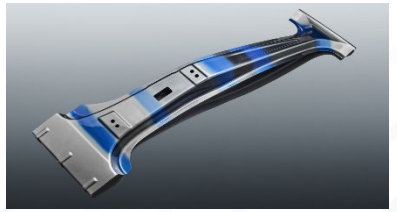
Rectangular Blanks [TRB]



Tailor Shaped Blanks [TRS]

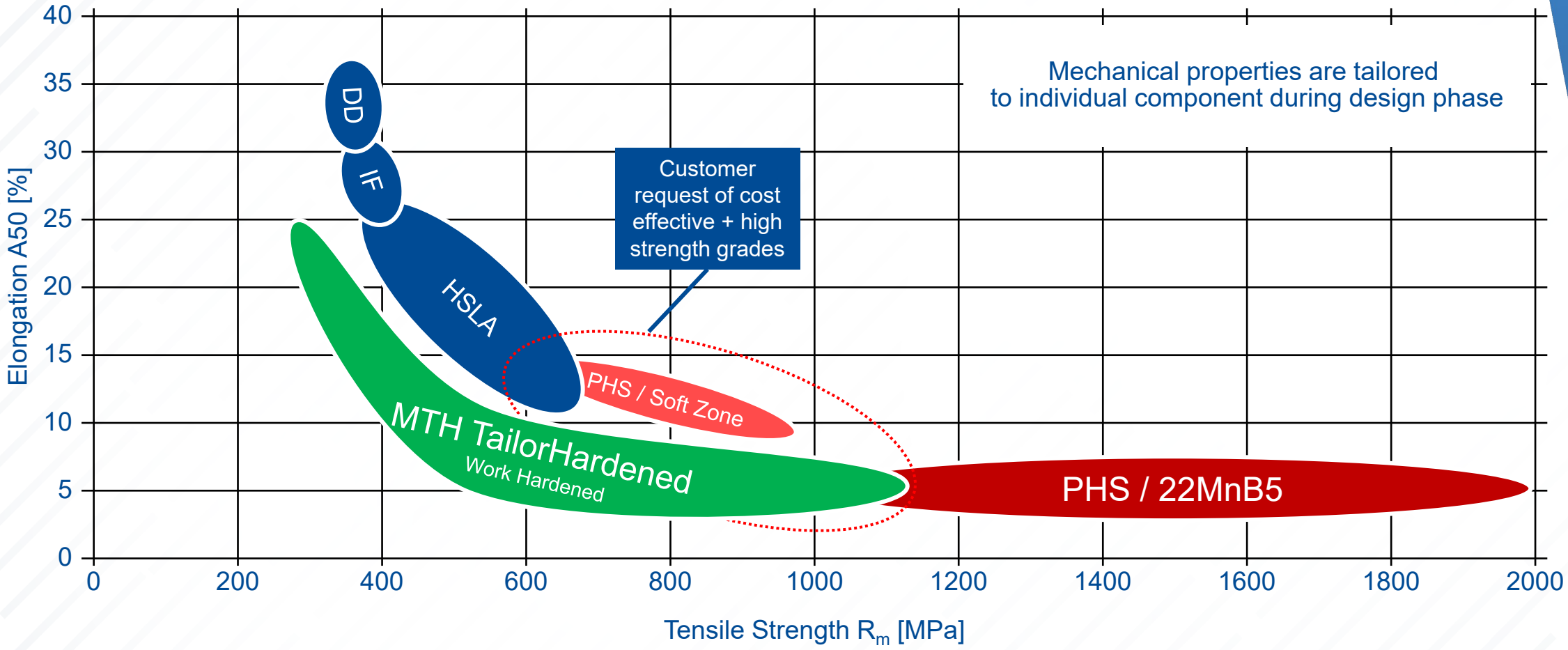


Hot Stampings & Assemblies [TRP-H] *)



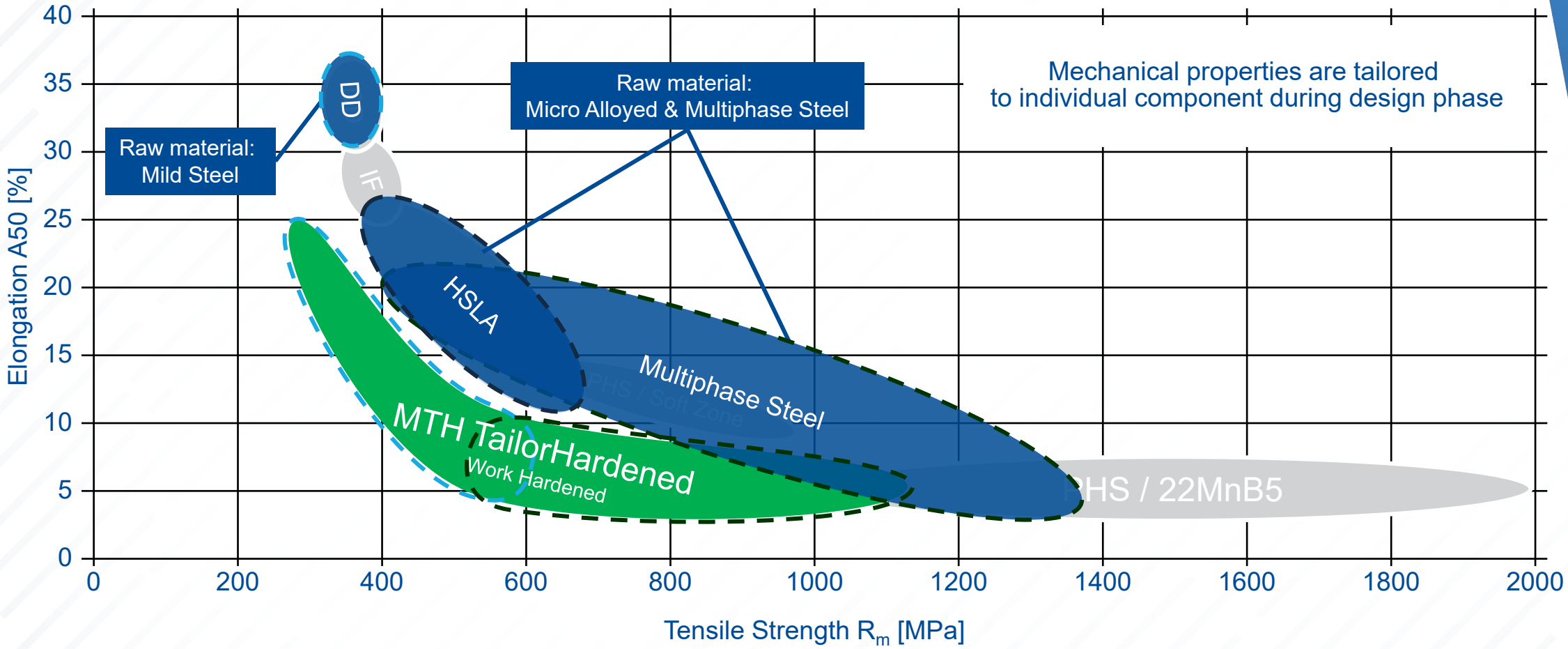
*) hot stamping lines already in serial production in Germany and China => planning to invest in hot stamping line in U.S I

TYPICAL MATERIAL PORTFOLIO



Cost effective alternative with mild steel / Cost effective + high strength with micro alloyed and multiphase steel

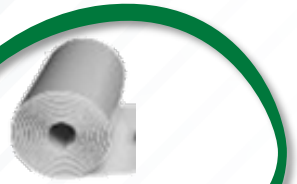
TYPICAL MATERIAL PORTFOLIO



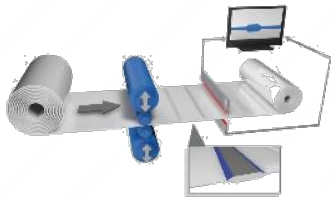
Cost effective alternative with mild steel / Cost effective + high strength with micro alloyed and multiphase steel

MUBEA TAILORHARDENED PRINCIPLE (WORK HARDENED)

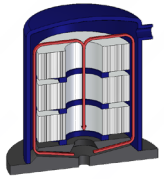
Conventional TRB process flow



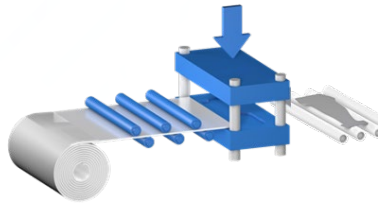
Raw Material
Grade 90



Flex Rolling



Batch Annealing



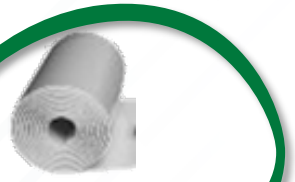
Blanking / Forming

CR420LA TRB

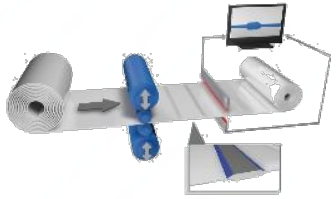
Homogeneous
mechanical properties

Mubea TailorHardened TRB ➡ Cost Effective + High Strength

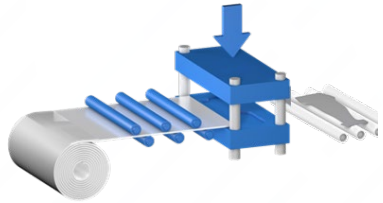
Mubea TailorHardened MTH420Y/550Y TRB



Raw Material
DD13



Flex Rolling



Blanking / Forming

Yield Strength depending on gauges
min. 420 MPa at highest gauge
min. 550 MPa at the lowest gauge

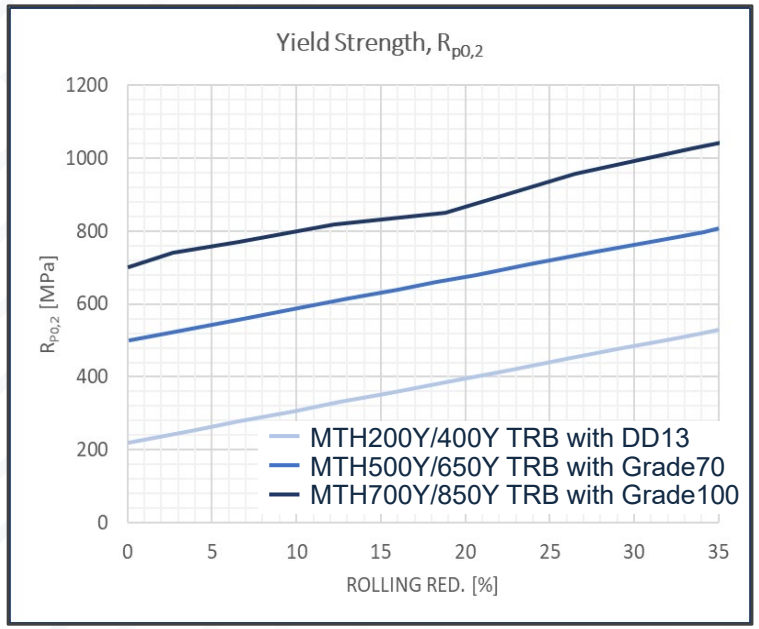
Cost effective due to use of lower grade raw material + omitted batch annealing process step

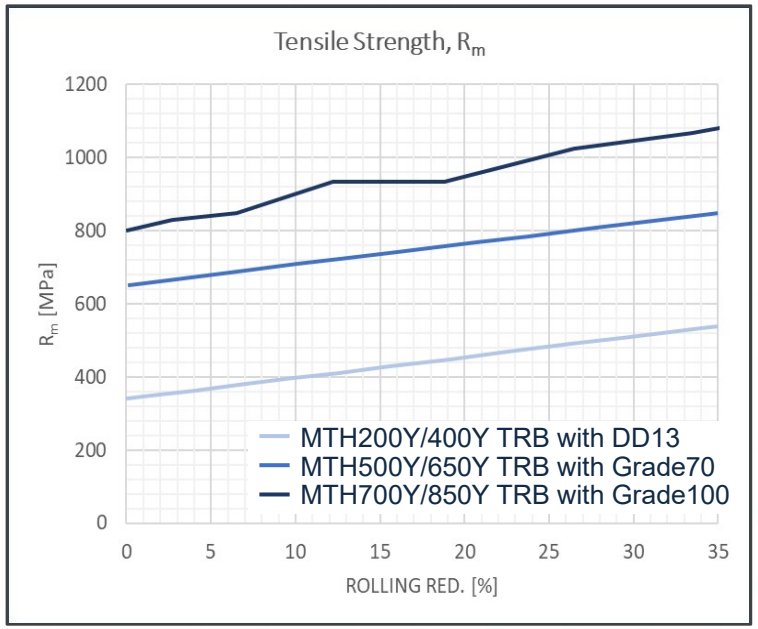
MUBEA TAILORHARDENED PROPERTIES

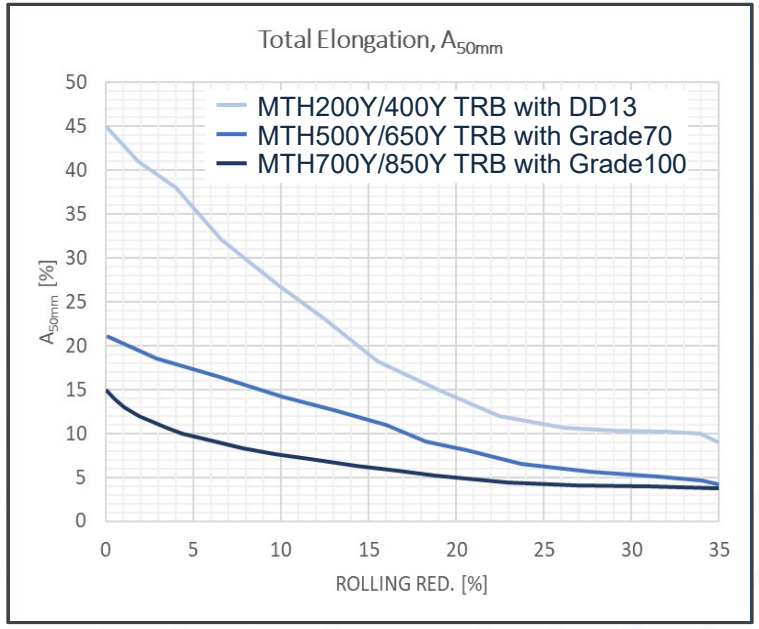
- Rolling of Single-Phase Ferritic Steels and lift it up to a higher strength level
- **High gauge** mechanical properties slightly elevated due to minor rolling reduction ➡ **high elongation**
- **Low gauge** mechanical properties increased due to major rolling reduction ➡ **high strength**

➔ Cost effective alternative to current TRB® cold forming portfolio

➔ Enhanced TRB® cold forming portfolio beyond CR500LA TRB®







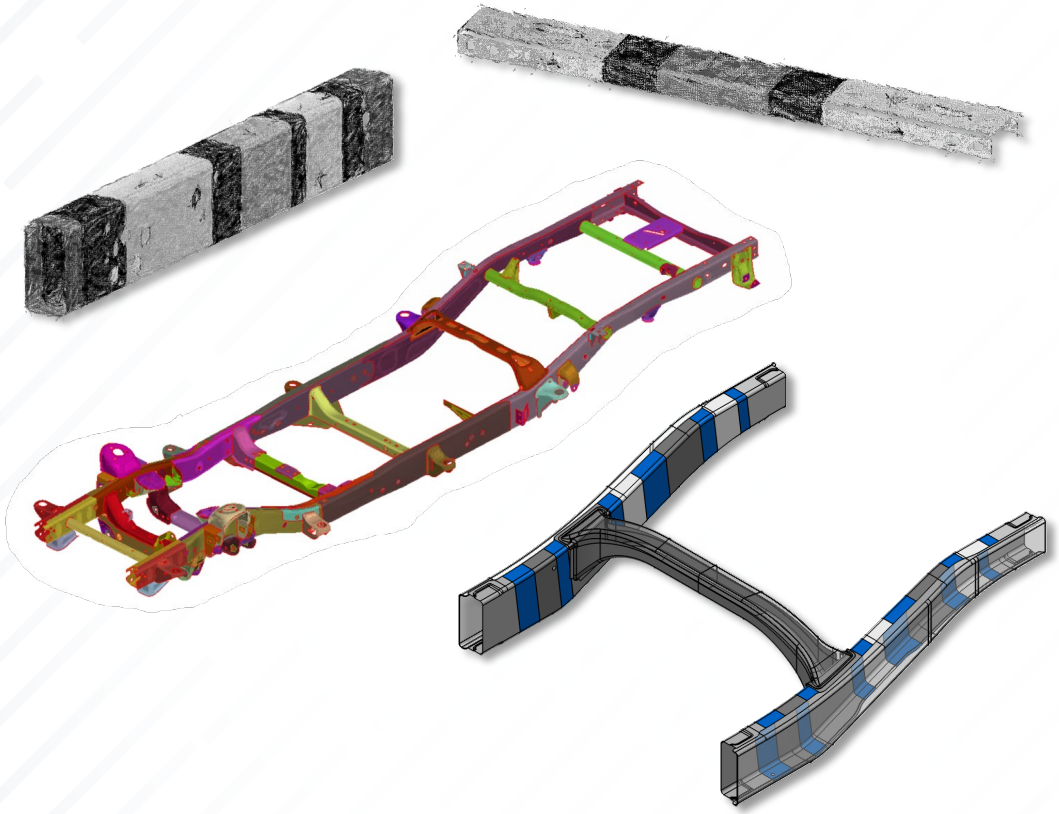
Cost effective alternative with mild steel / Cost effective + high strength with micro alloyed and multiphase steel

TAILORHARDENED POTENTIAL APPLICATION

20 YEARS GDIS

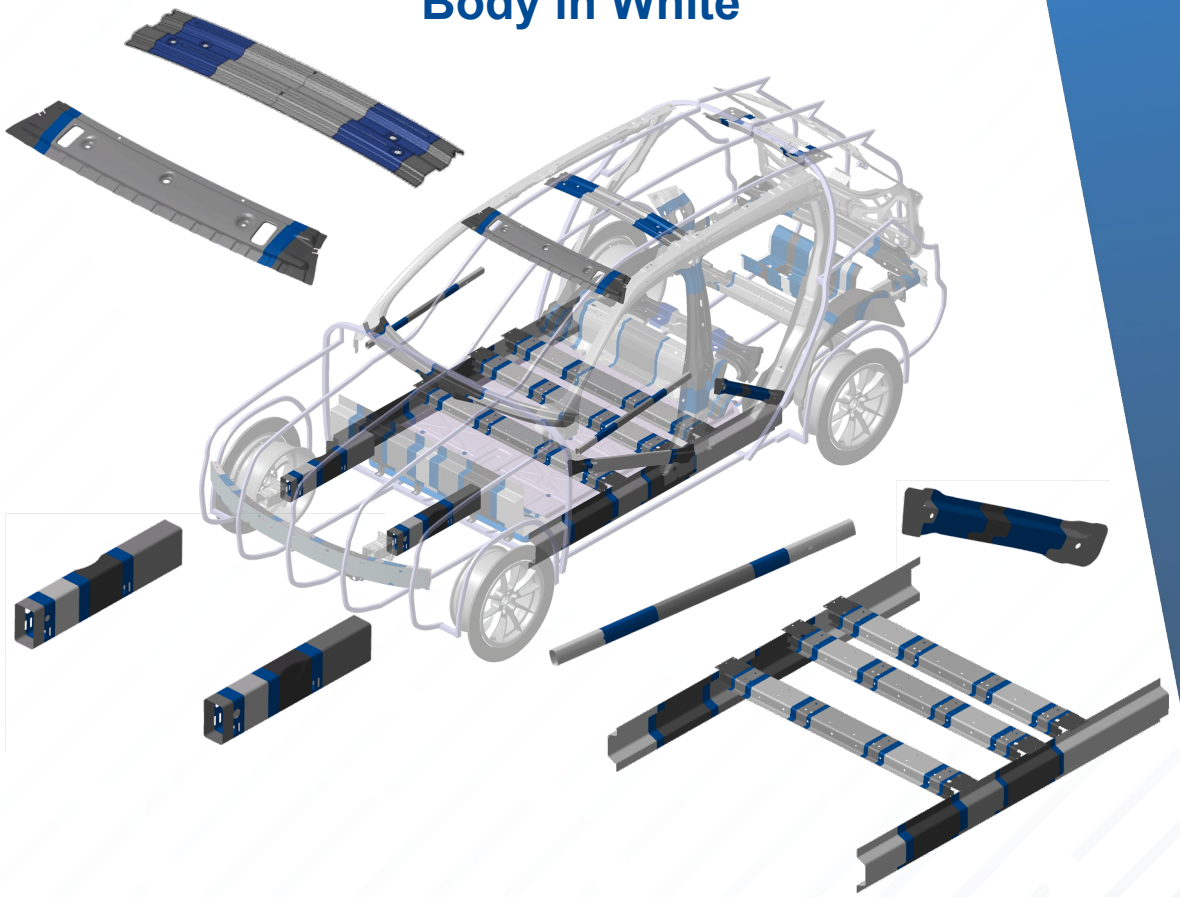
Targeted applications are Straight Regular Profiles with minor deep drawing sections

Ladder Frame



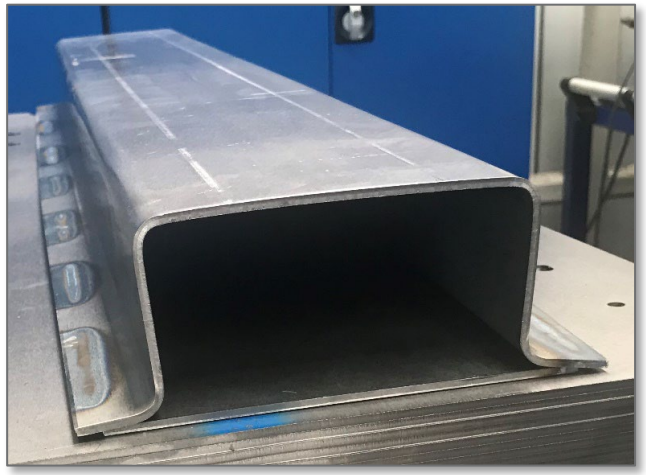
Ongoing investigations include successful physical testing

Body in White



Potential applications driven by BEV architectures

TAILORHARDENED DEFORMATION BEHAVIOR

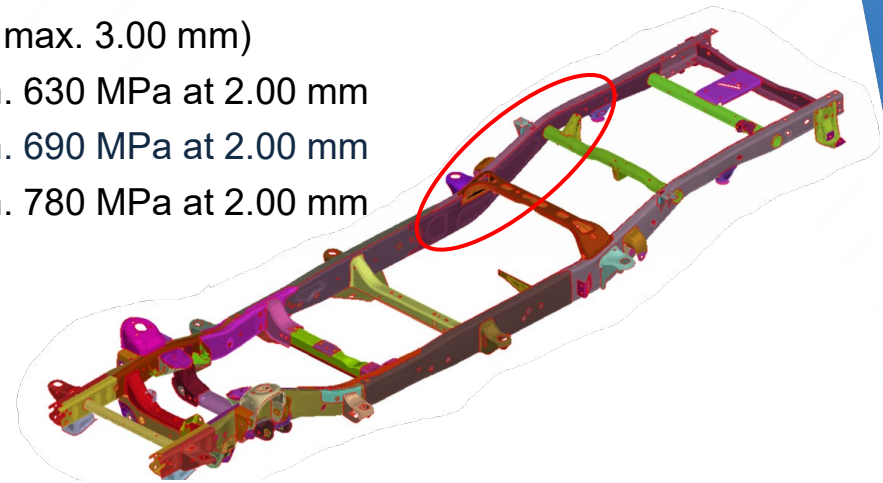


- Sample assemblies to conduct 3-point bending trials composed of:
  - Hat Profile geometry with MTH550Y/700Y TRB and MTH420Y/580Y TRB
  - Closing Plate with CR500LA joined by laser welding
- Initial 3-point bending trials with 2 materials…
  - have shown a folding behavior like expected
  - no cracking appeared in any of the parts

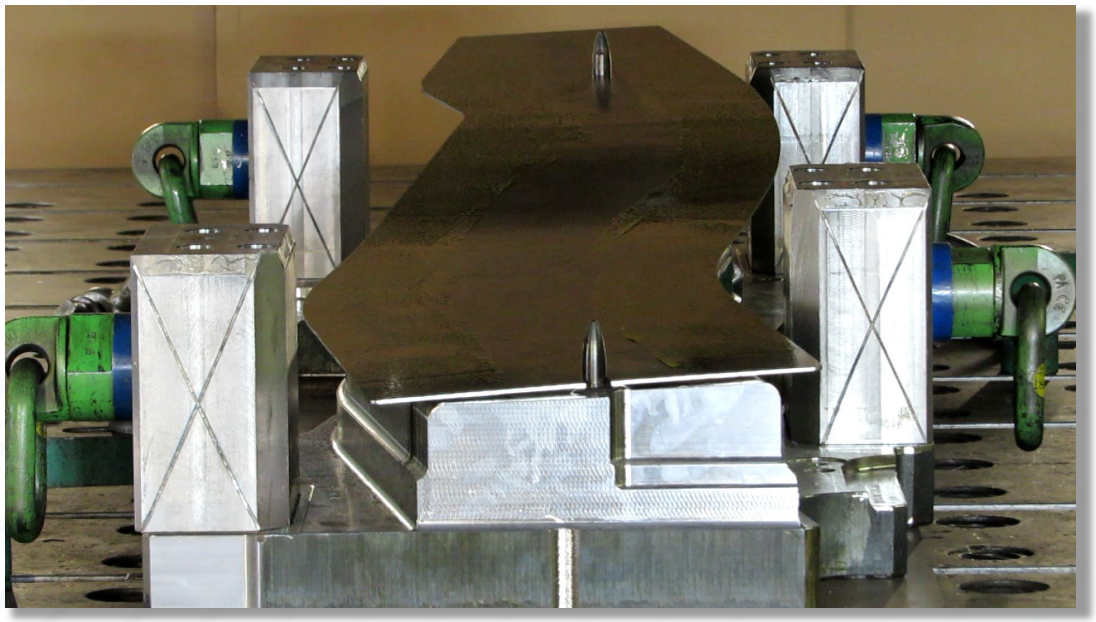
Good deformation behavior in areas with high rolling reductions (high Yield Strength / lower Elongation)

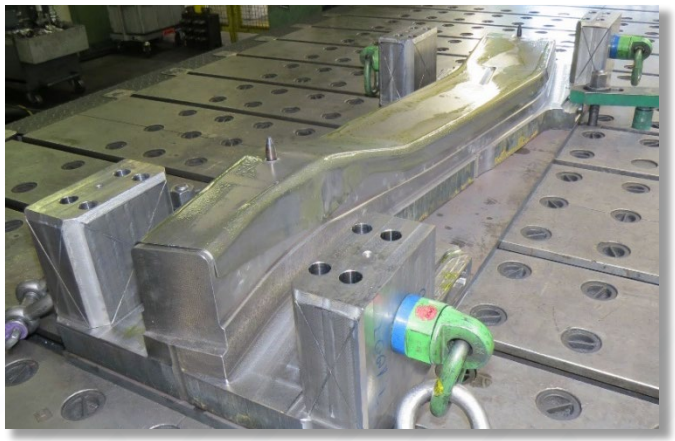
TAILORHARDENED FORMABILITY

- Formability trials of Kick-Up Rails with minor deep drawing sections
- 3 different raw materials with same final thickness profile (min. 2.00 mm – max. 3.00 mm)
  - DD13 ➡ MTH550Y/630Y TRB min. 550 MPa at 3.00 mm / min. 630 MPa at 2.00 mm
  - Grade45 ➡ MTH560Y/690Y TRB min. 560 MPa at 3.00 mm / min. 690 MPa at 2.00 mm
  - Grade60 ➡ MTH590Y/780Y TRB min. 590 MPa at 3.00 mm / min. 780 MPa at 2.00 mm
- Same final thickness profile (min. 2 mm – max. 3 mm)



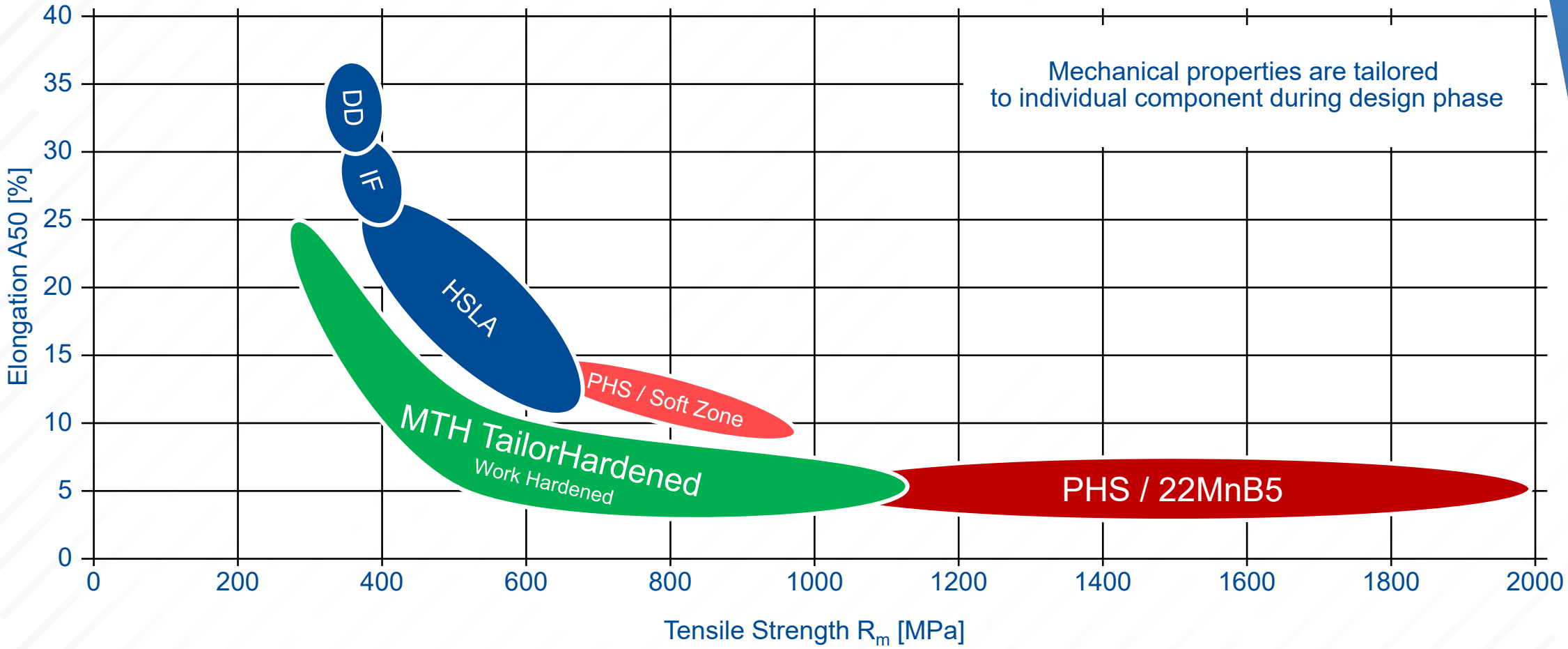
Source: https://www.nhtsa.gov/crash-simulation-vehicle-models



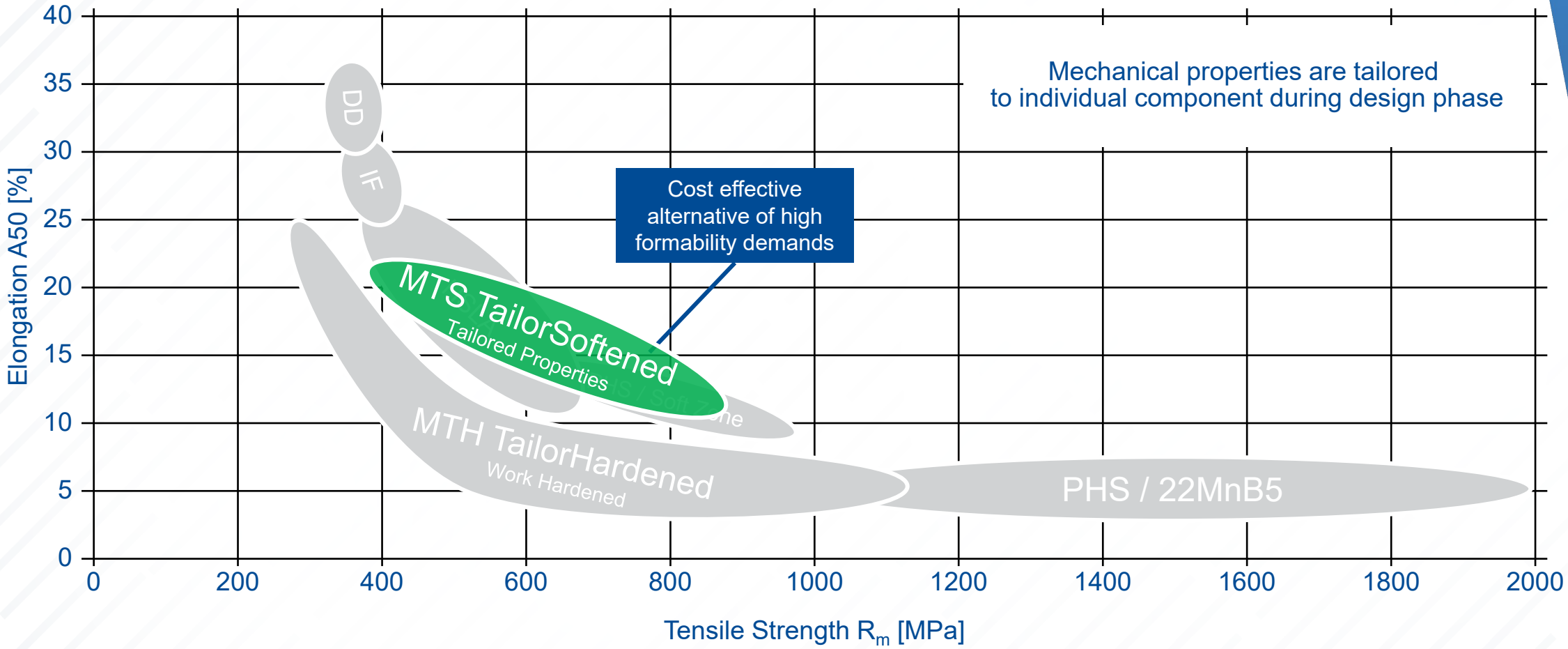


No major issues detected ➡ good results even before spring back compensation

TYPICAL MATERIAL PORTFOLIO

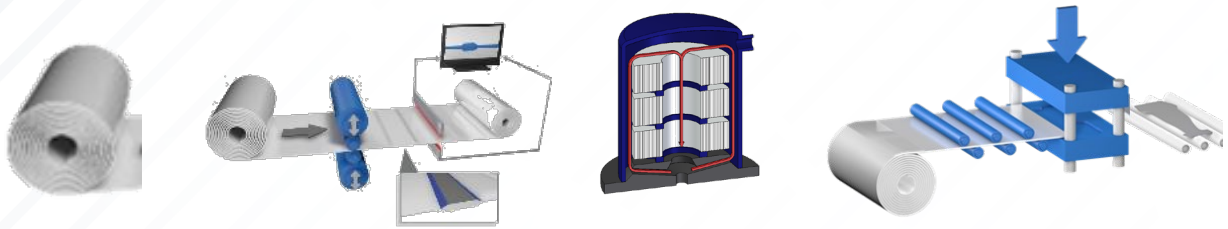


TYPICAL MATERIAL PORTFOLIO



MUBEA TAILORSOFTENED PRINCIPLE

Conventional TRB process flow



Raw Material
Grade 90 **x 3.00 mm**

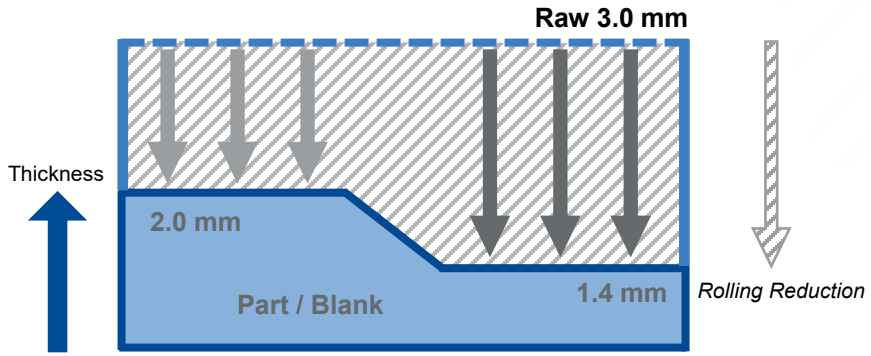
Flex Rolling

Batch Annealing

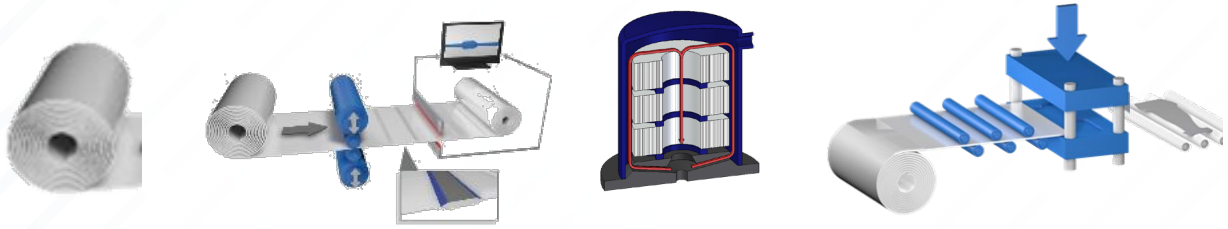
Blanking / Forming

Homogeneous mechanical properties

CR500LA TRB



Conventional TRB process flow with lower rolling reduction



Raw Material
Grade 90 **x 2.20 mm**

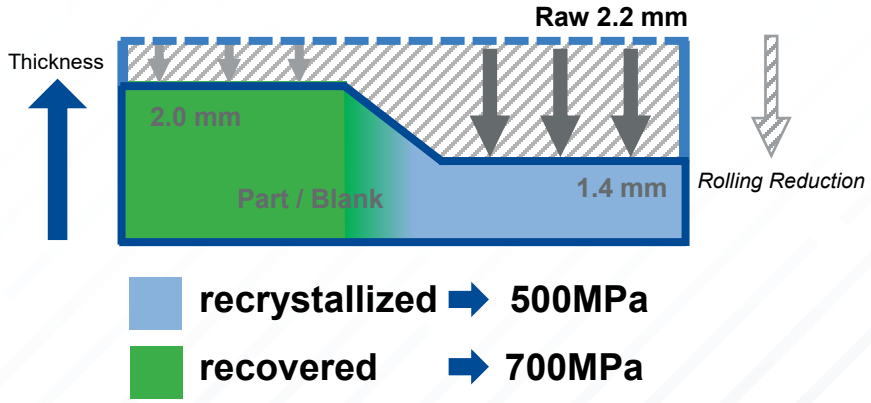
Flex Rolling

Batch Annealing

Blanking / Forming

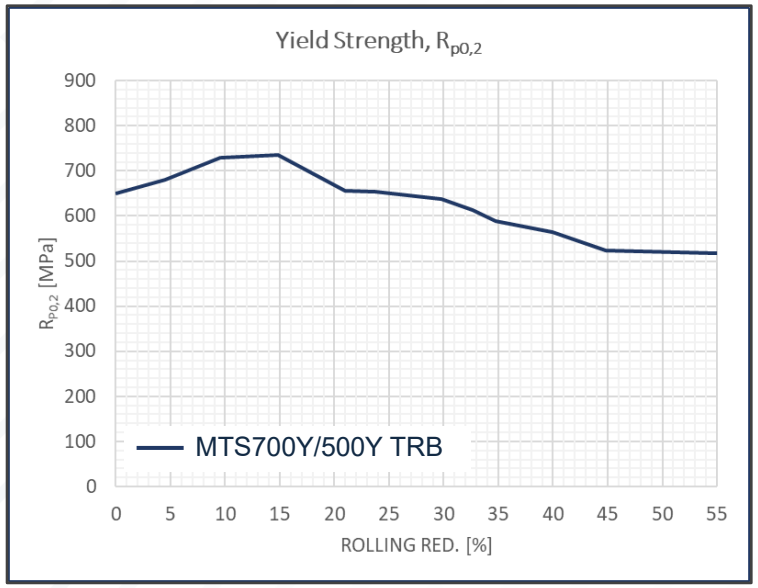
Mubea TailorSoftened

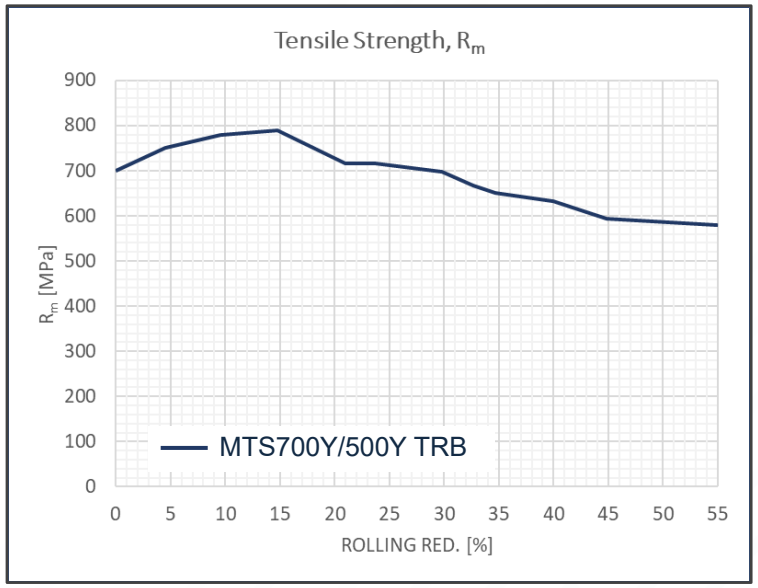
MTS700Y/500Y TRB

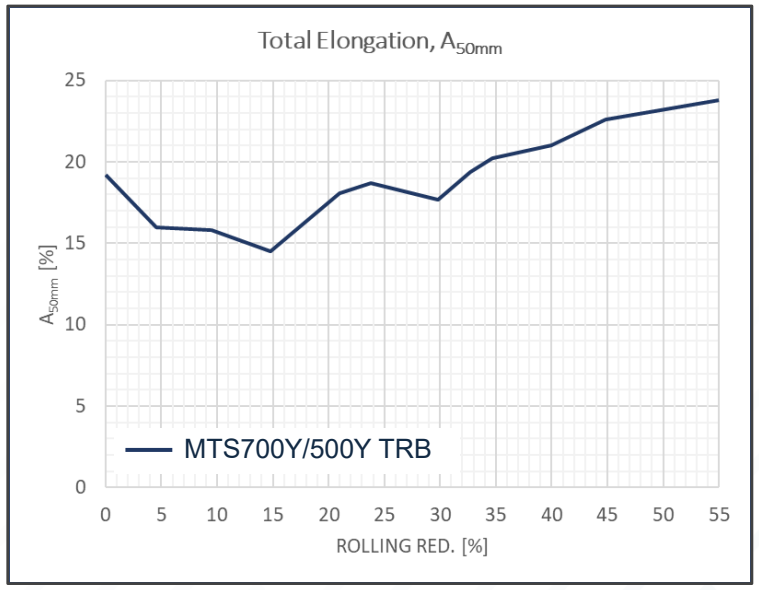


MUBEA TAILORSOFTENED PROPERTIES

- Rolling of Single-Phase Ferritic Steels with **low** and **high** rolling reductions
- **High gauge / low rolling reduction = high strength ➡ crash collapse area / definition of reaction force**
- **Low gauge / high rolling reduction = high formability ➡ high elongation desirable for complex geometry**
- Mechanical properties increased by rolling reductions **< 10%**
- Mechanical properties decreased at rolling reductions **> 30%**



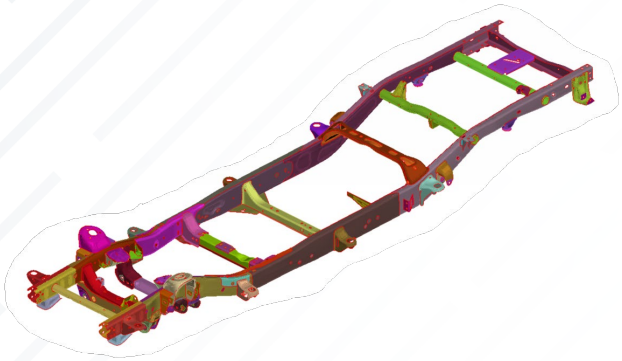


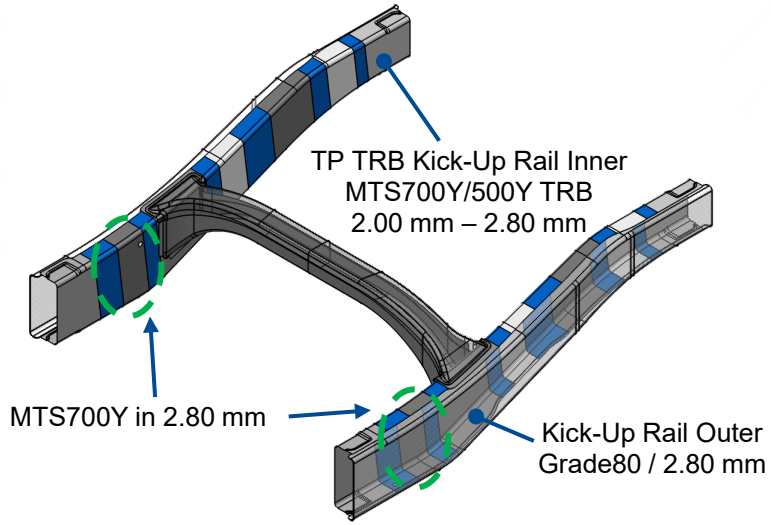


Cost effective cold forming alternative with two property zones ➡ high strength and high formability

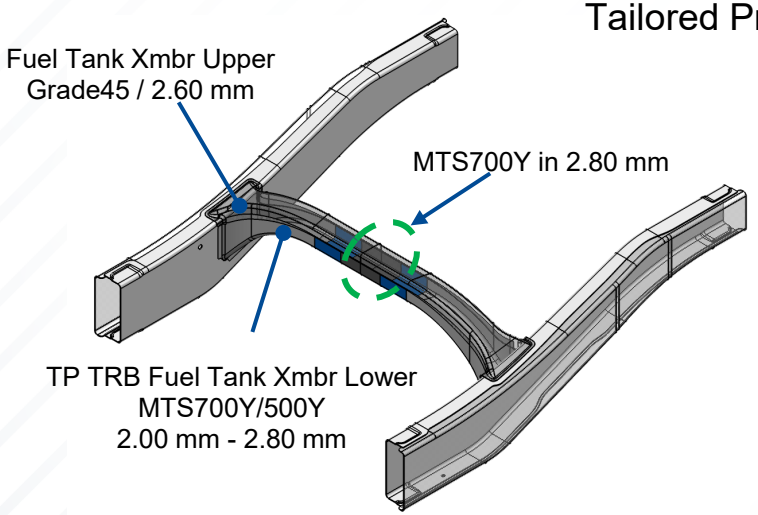
MTS POTENTIAL APPLICATION

Ladder Frame



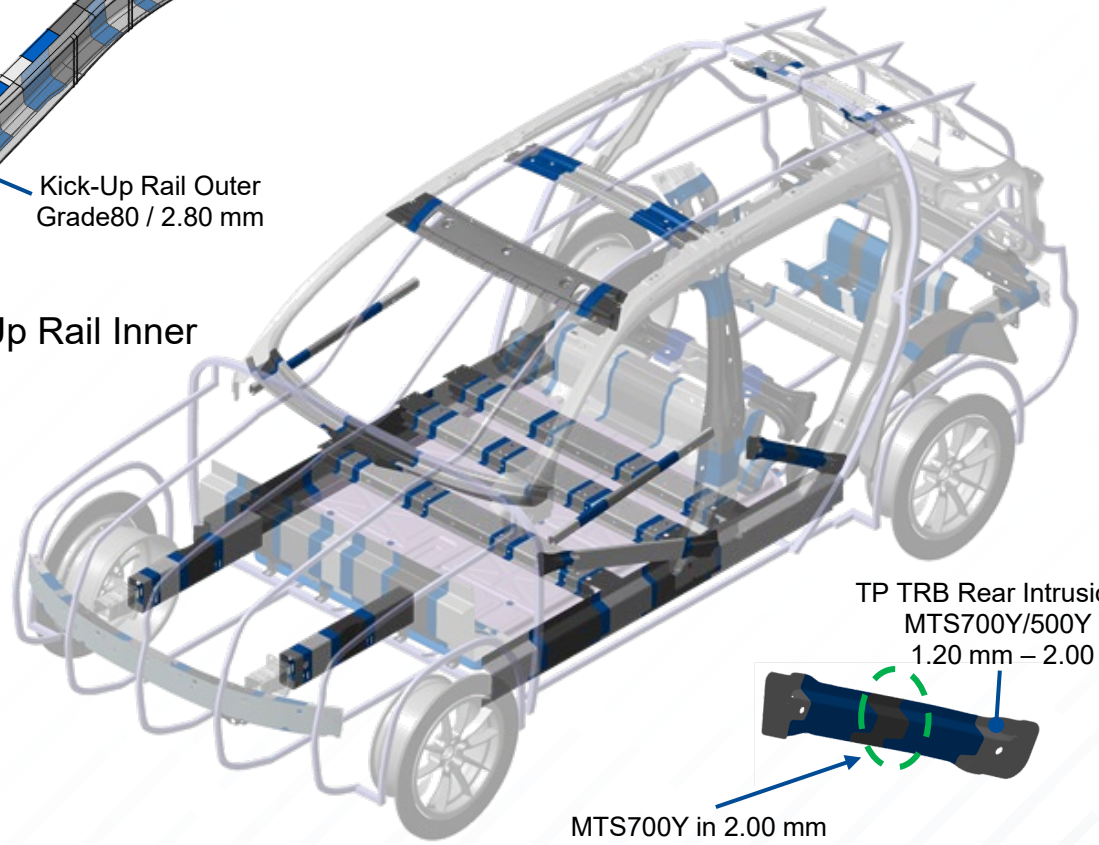


Tailored Properties TRB Kick-Up Rail Inner



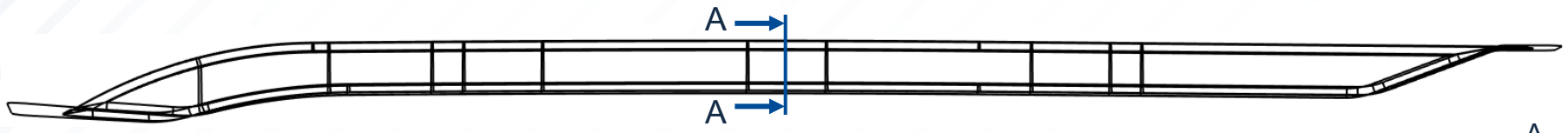
Tailored Properties TRB Fuel Tank Cross Member

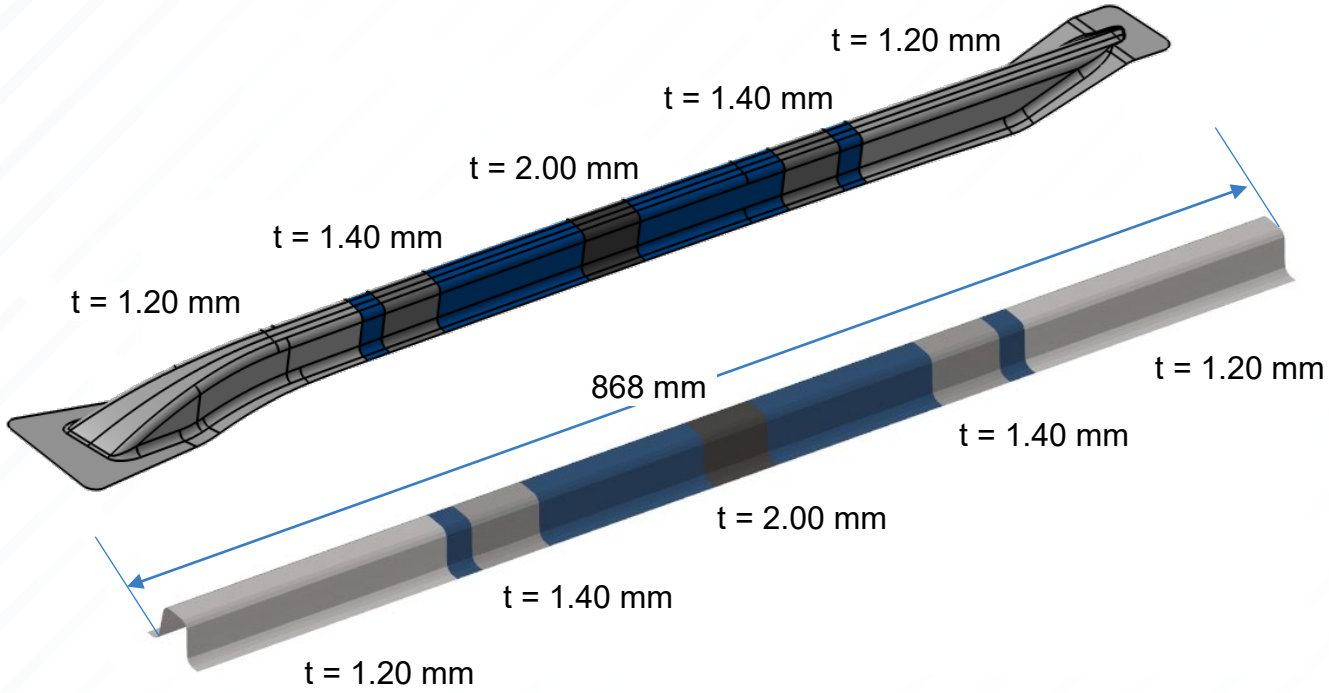
Body in White

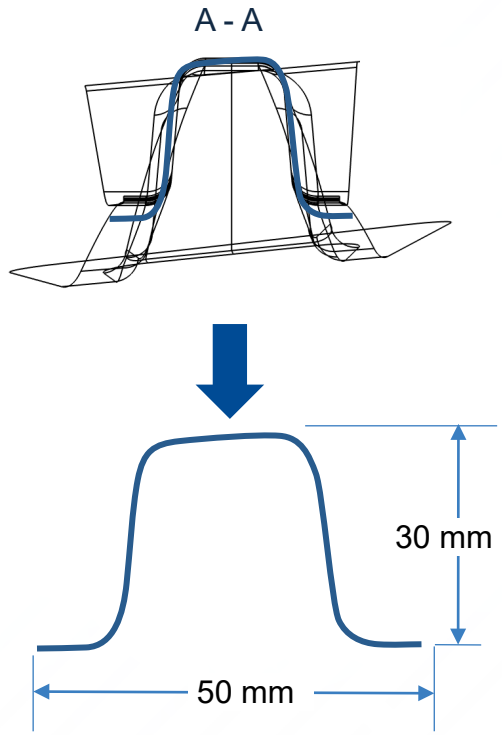


Tailored Properties TRB Front & Rear Intrusion Beams

MTS APPLICATION DOOR INTRUSION BEAM

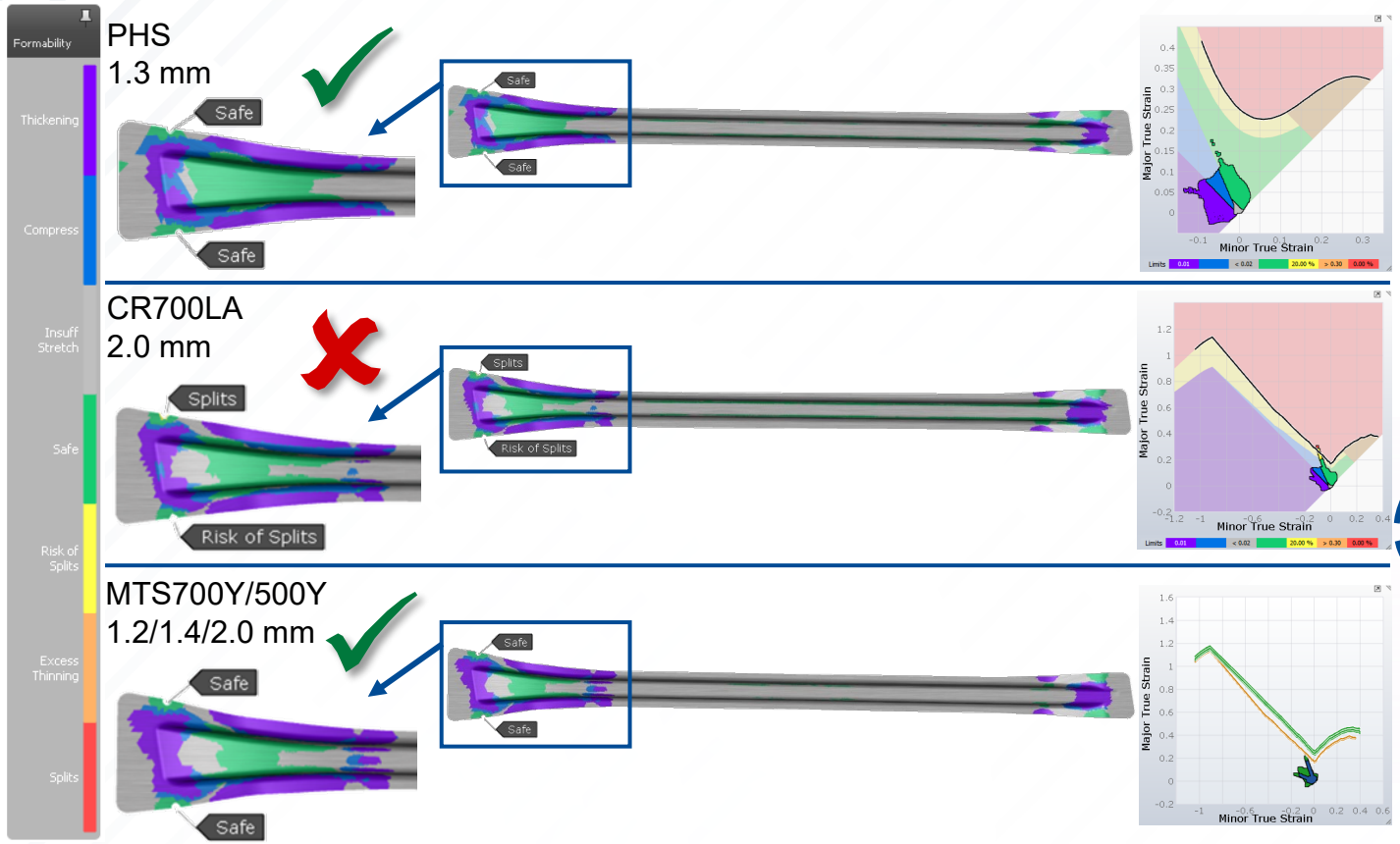


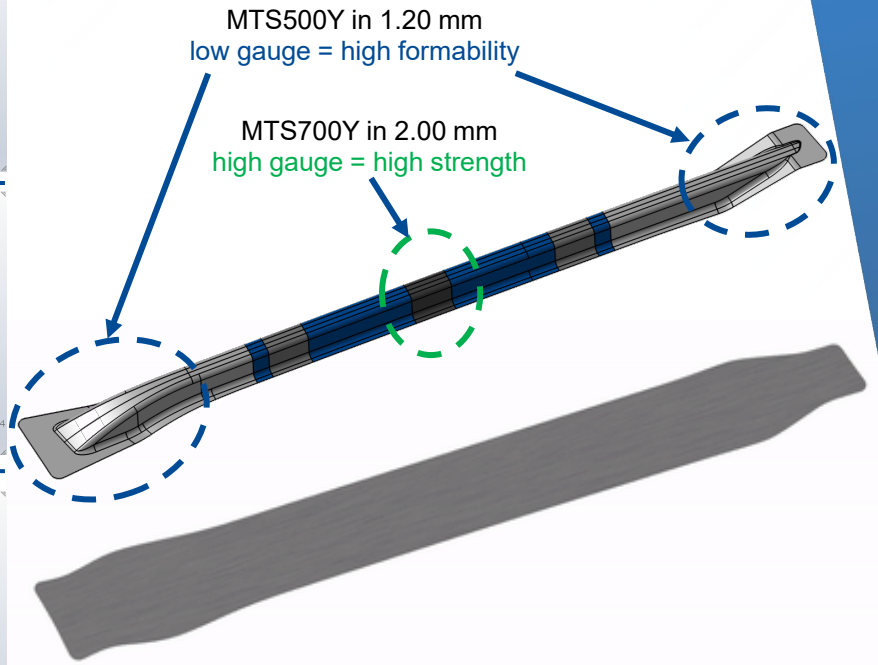




- Mubea generic Door Intrusion Beam concept geometry
- U-Channel design with same center cross section and percent rolling reduction
- Surrogate U-Channel part used for material card validation

MTS INTRUSION BEAM FORMABILITY

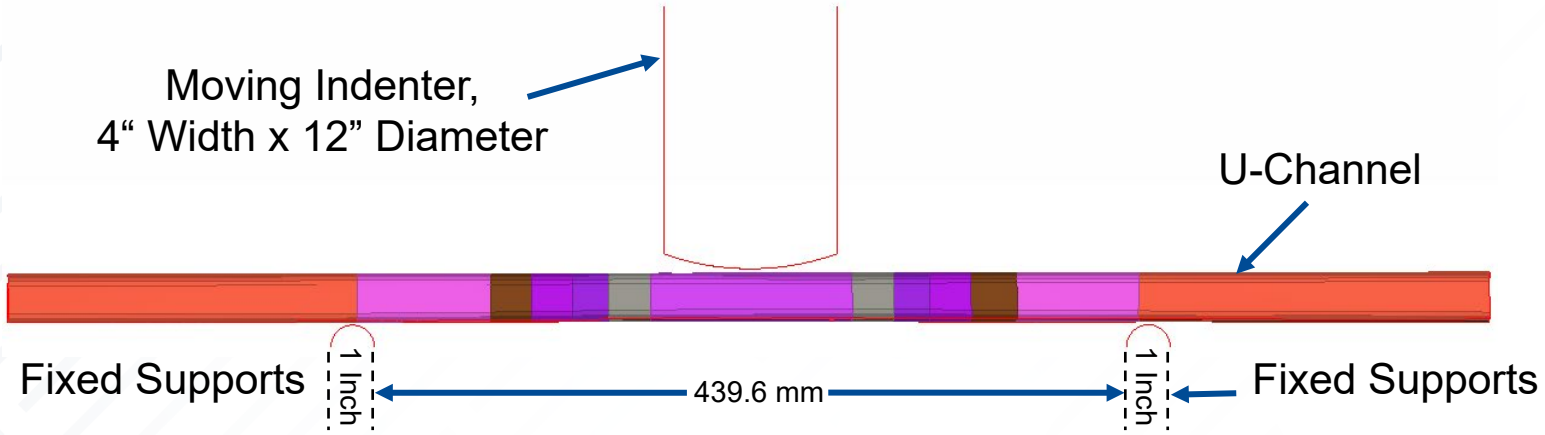


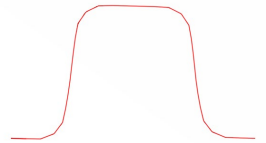


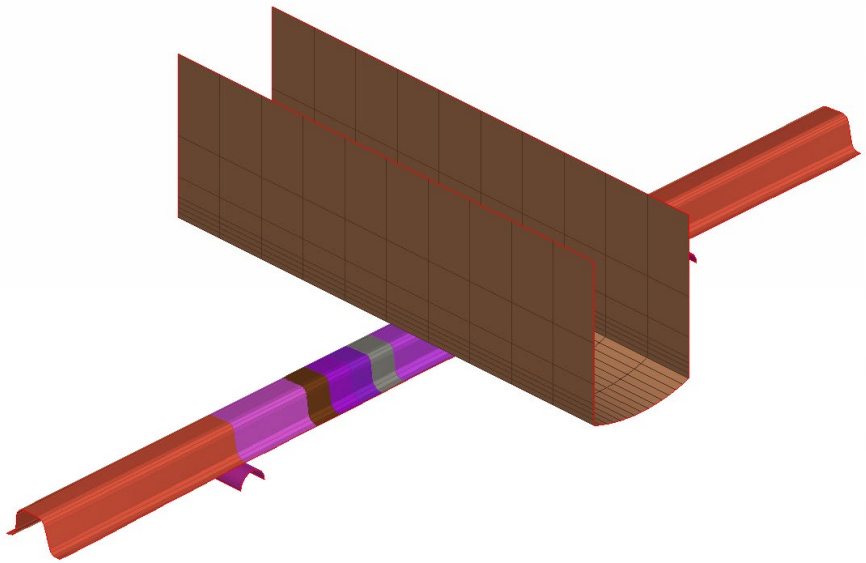
- Hot forming simulation with 1.30 mm monolithic PHS material => safe
- Cold forming simulation with 2.00 mm monolithic CR700LA => not feasible
- Cold forming simulation with 1.20/1.40/2.00 mm MTS700Y/500Y => safe

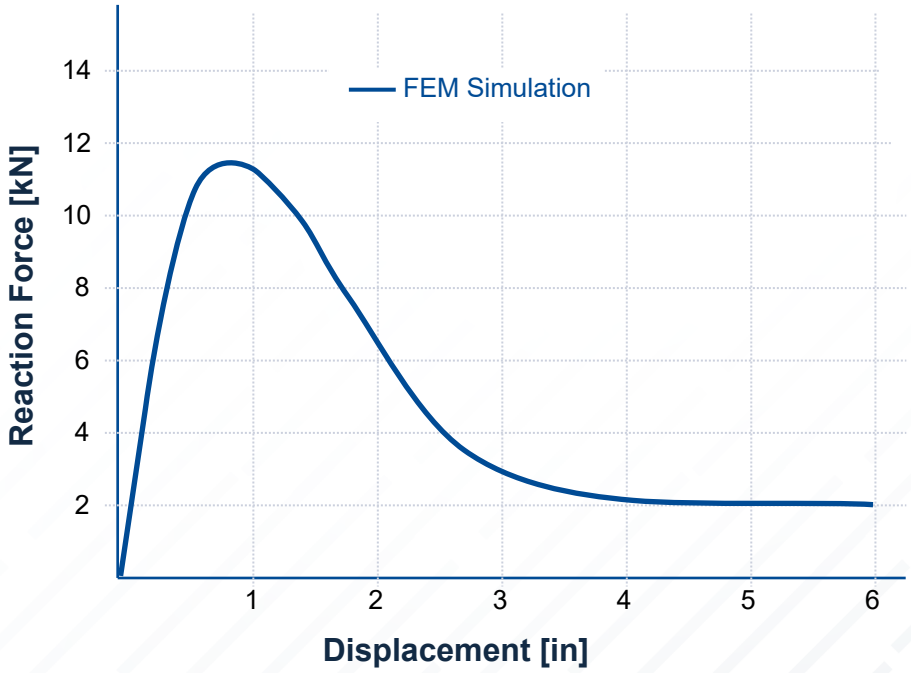
Cost effective cold forming alternative with two property zones ➡ high strength and high formability

MTS 3-POINT BENDING SIMULATION



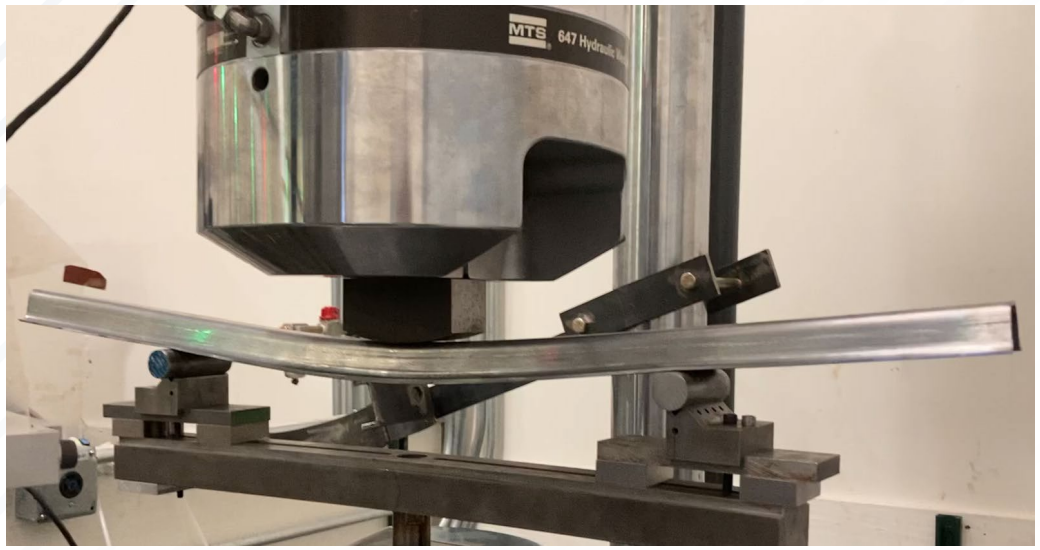




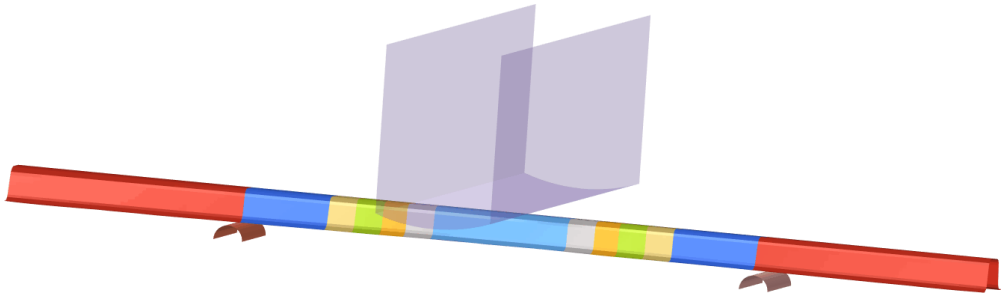


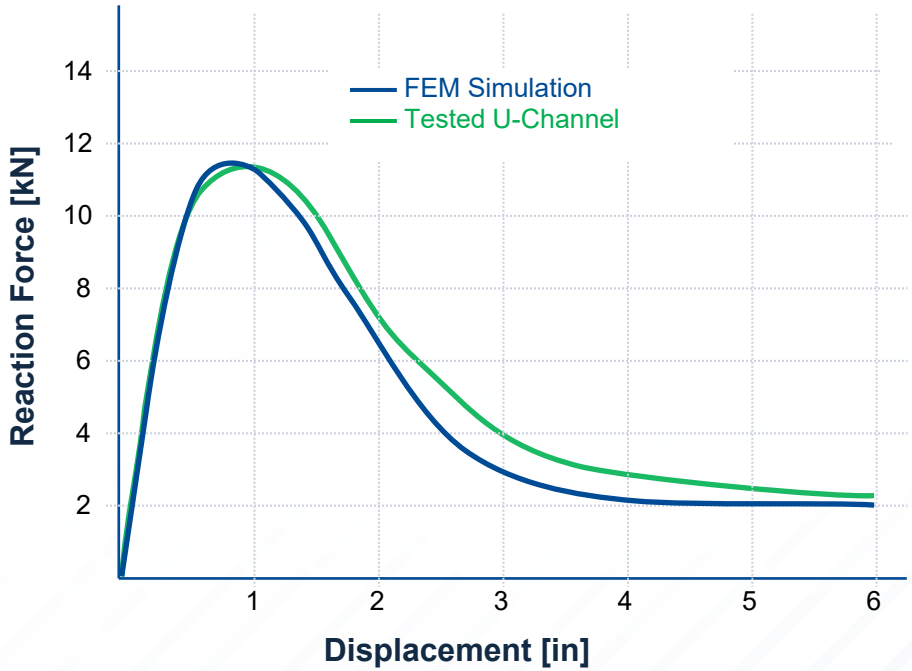
- Total enforced Displacement: 3 inch to 6 inch

MTS 3-POINT-BENDING VALIDATION



Deformed part after 6“ displacement





Material card for FEM simulation shows good correlation between real test and simulation

SUMMARY

Mubea TailorHardened MTH

- Introducing cost effective steel grades for cold forming steel with variable gauges
- Cost effective TRB® cold forming portfolio with mild steel raw material
  - up to strength level of CR550LA
  - MTH200Y/400Y TRB – MTH550Y/630Y TRB under development
- Enhanced TRB® cold forming portfolio with Micro Alloyed and Multiphase steel raw material
  - Strength level ≥ CR550LA for Ultra High Strength steel application
  - MTH340Y450Y TRB – MTH700Y/850Y TRB under development

Mubea TailorSoftened MTS

- Introducing (2) different strength levels in one part with flexible gauges
- Crash Resistance
  - High Gauge ➡ Skim passed, properties similar to hot rolled raw material
- Energy Absorption / High Formability
  - Low Gauge ➡ Standard rolling reductions, properties similar to typical TRB® grades
- “New Steel Family” under development
  - MTS315Y/240Y ; MTS420Y/300Y ; MTS500Y/340Y
  - MTS550Y/380Y ; MTS600Y/420Y ; MTS700Y/500Y

Mubea

Drive e-mobility with Mubea

THANK YOU VERY MUCH

FOR YOUR ATTENTION !

20 YEARS GDIS

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