Full digitalization approach to strengthen Stamping & Body-in-White Engineering

GDIS

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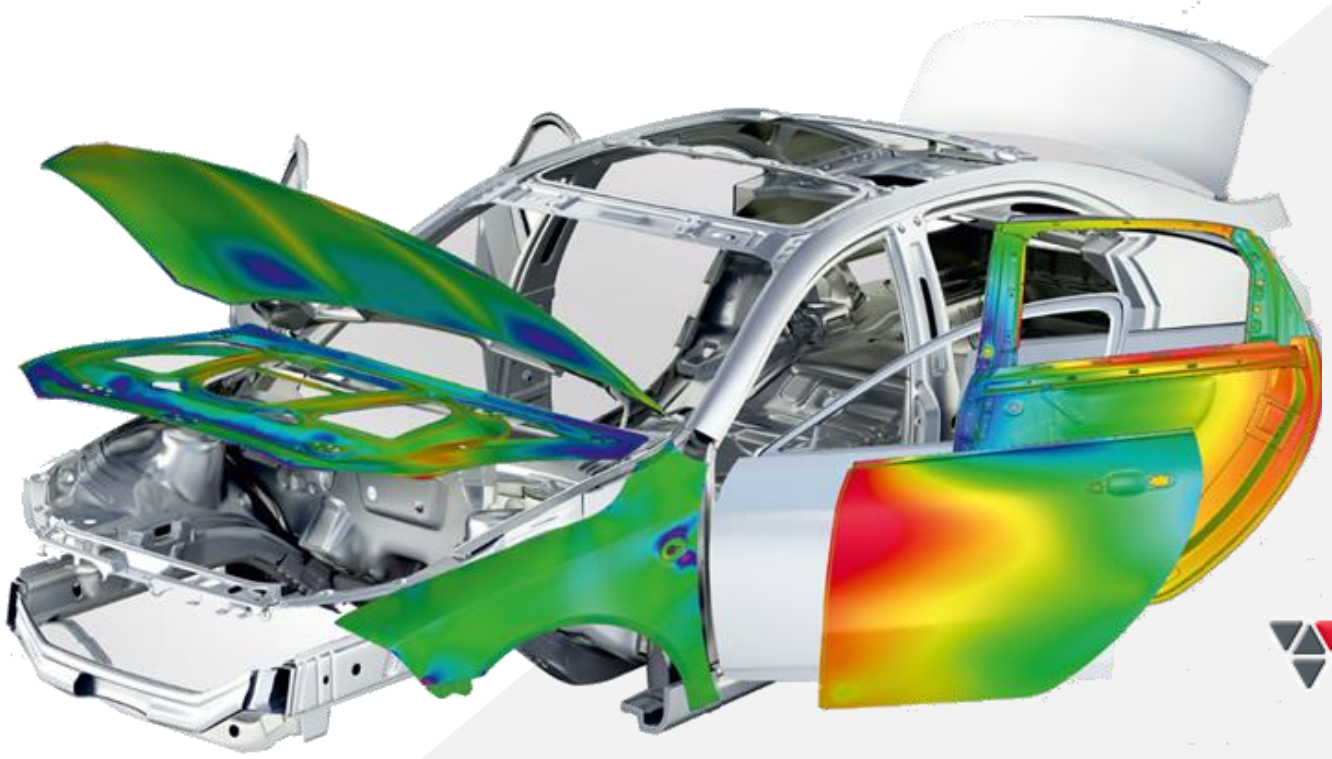
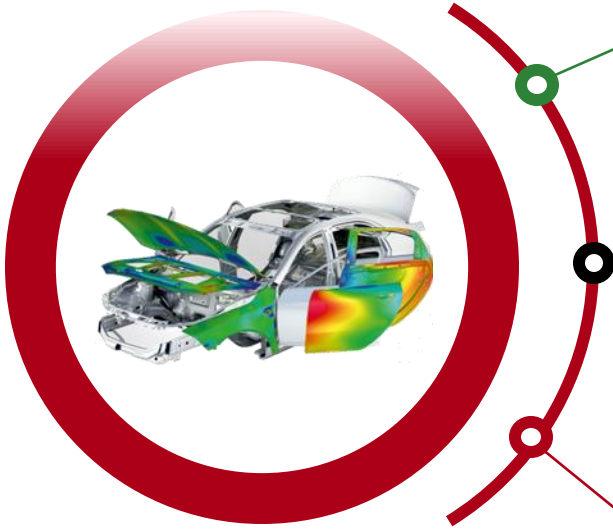


AUTOFORM
Forming Reality

Agenda



- Bridging Stamping & BiW Engineering
- Industrial Applications
- Conclusions & Takeaways

AutoForm Solutions

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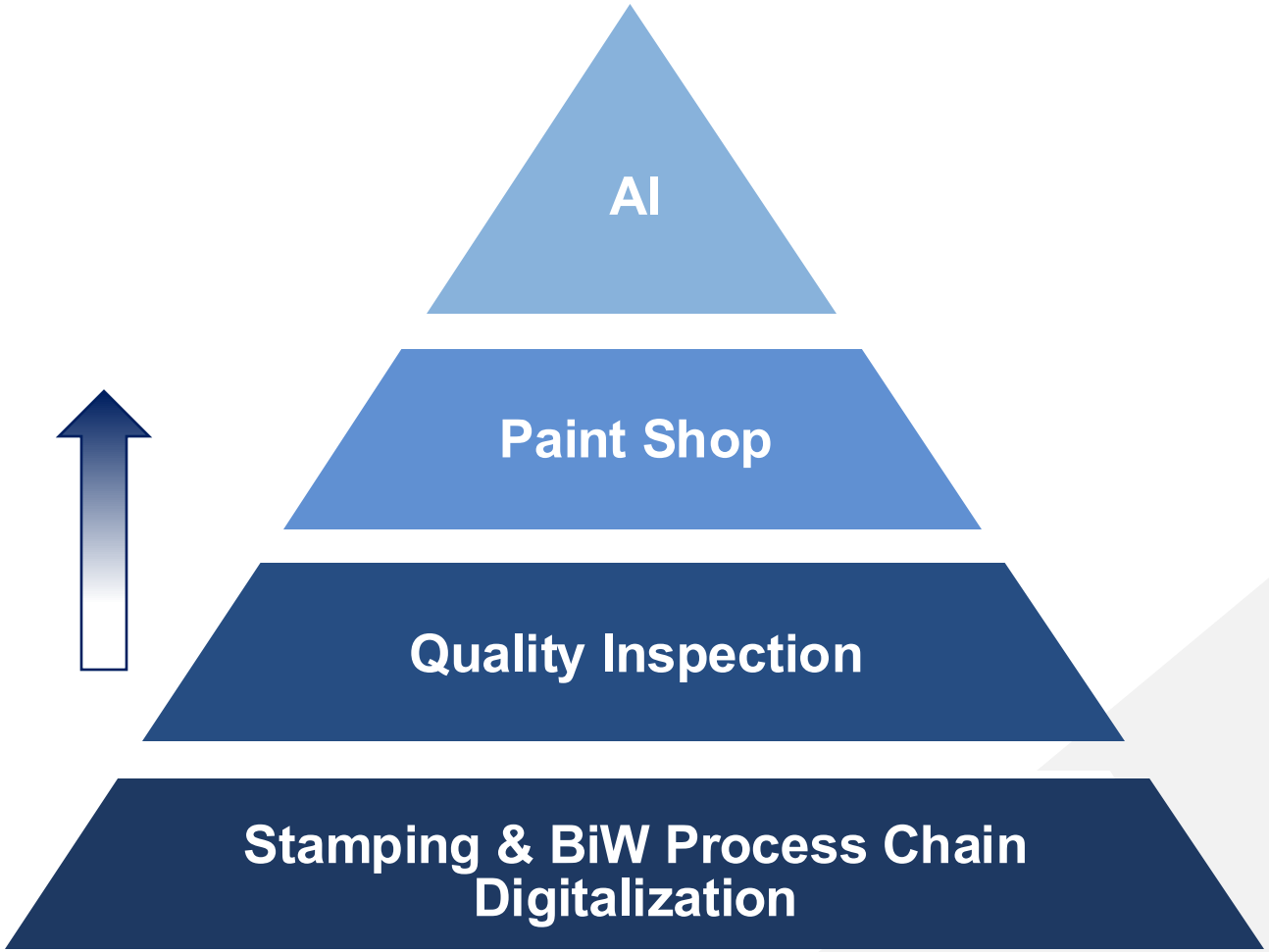
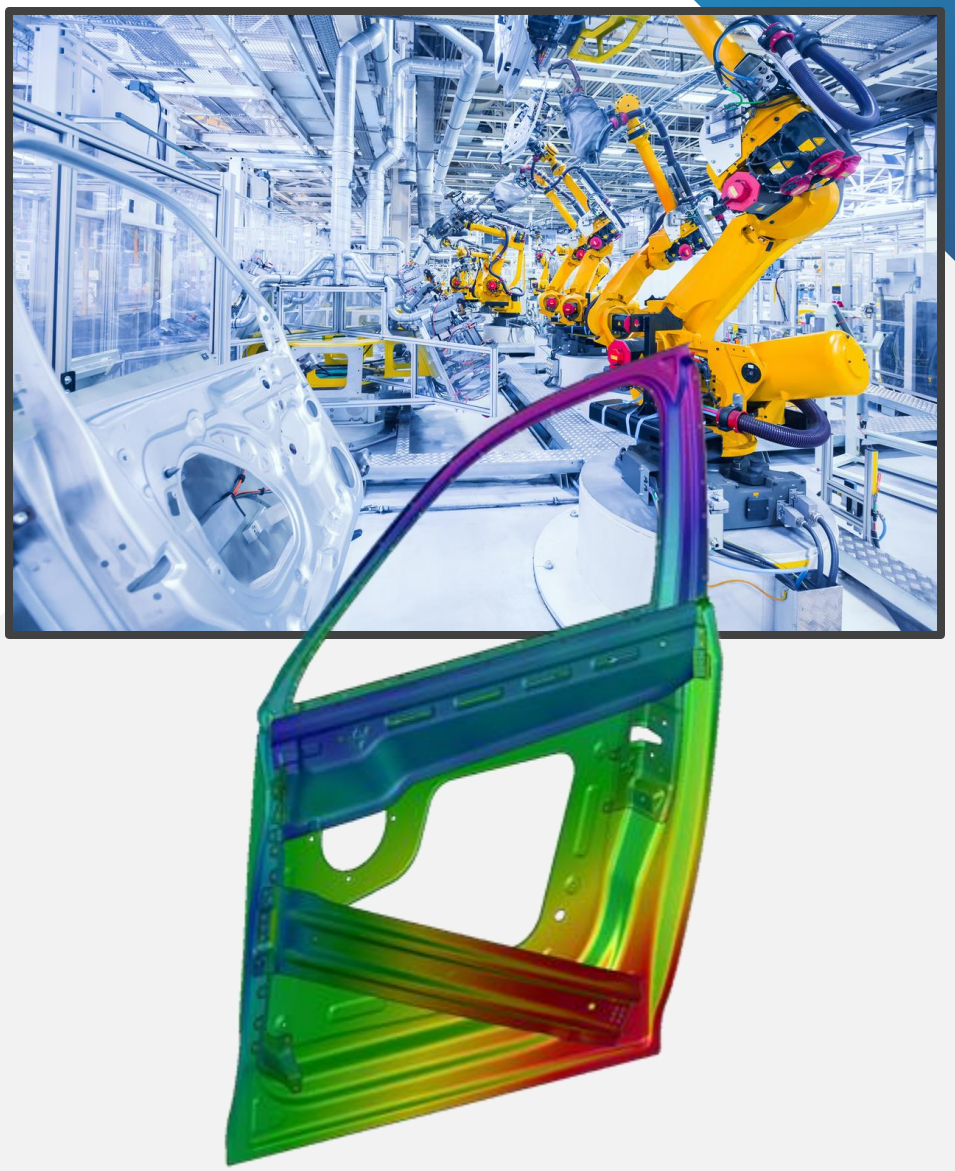
AutoForm **Digital Process Twin** covers the entire process chain





BiW assembly process simulation

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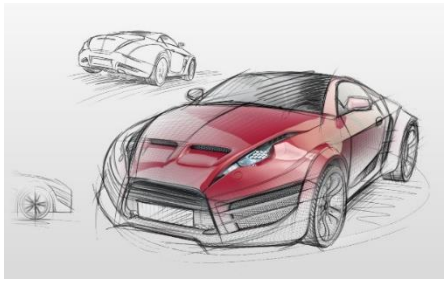
Concept, Styling | Product Design | Production Planning | Process Engineering | Tool Design and Manufacturing | Tryout | Part Production | BiW Assembly

Product Development



Early Planning

Process & Tooling

Tryout & Pre-Series

Early Process Feasibility

(CAD-0 geometries / Nominal Parts)

Process Engineering

(Stamping Results)

Process Improvement

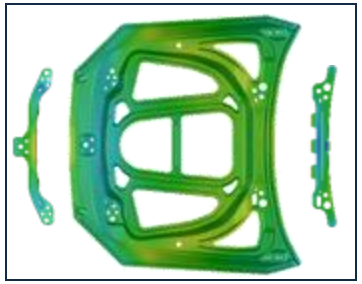
(Actual Part Scans)

Source of distortions in assemblies

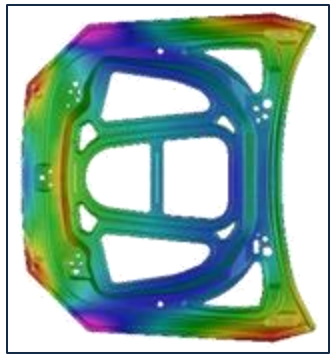
Connect Stamping Engineering & BiW Engineering

Joining induced distortions

+



Forming induced distortions



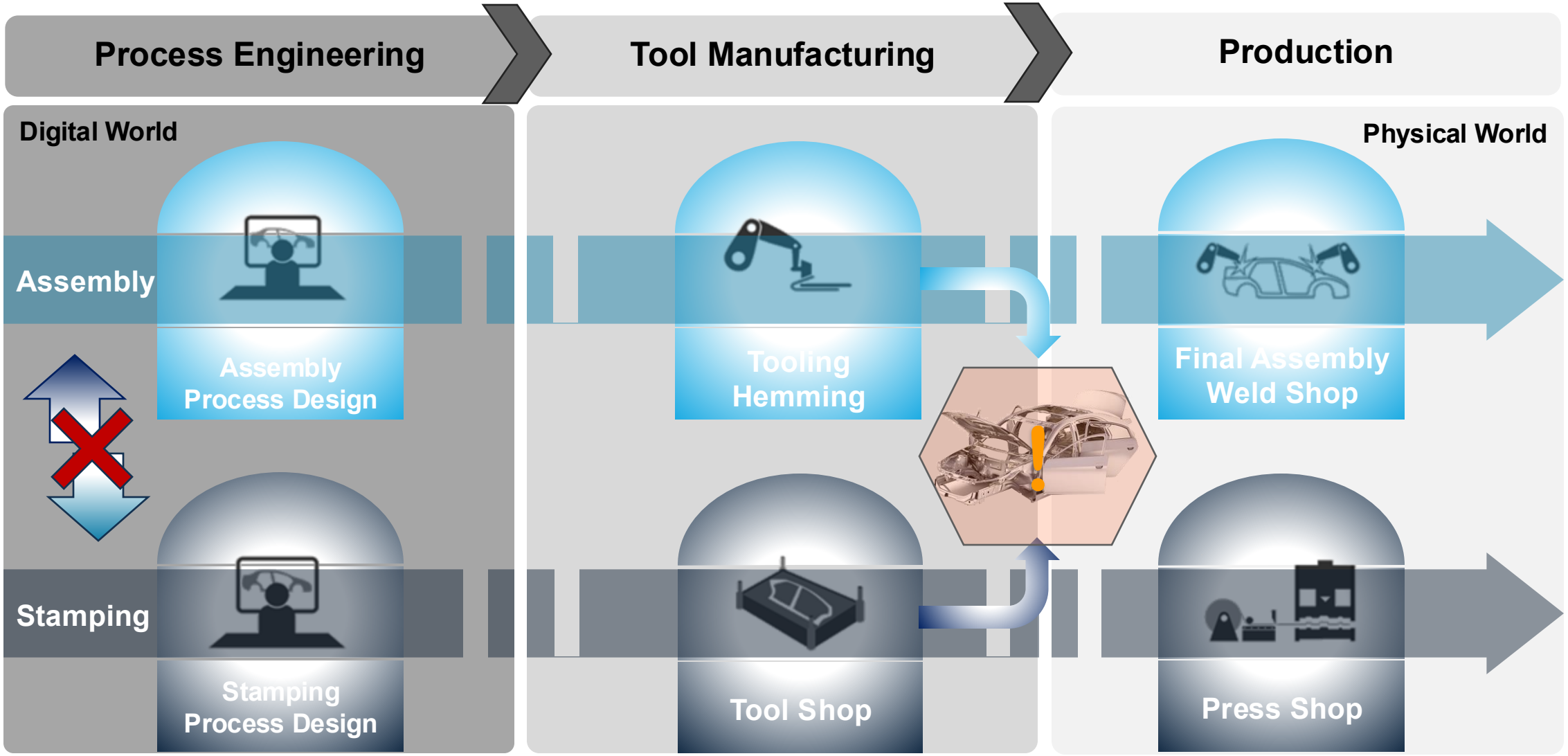
Assembly distortions

Stamping Engineering

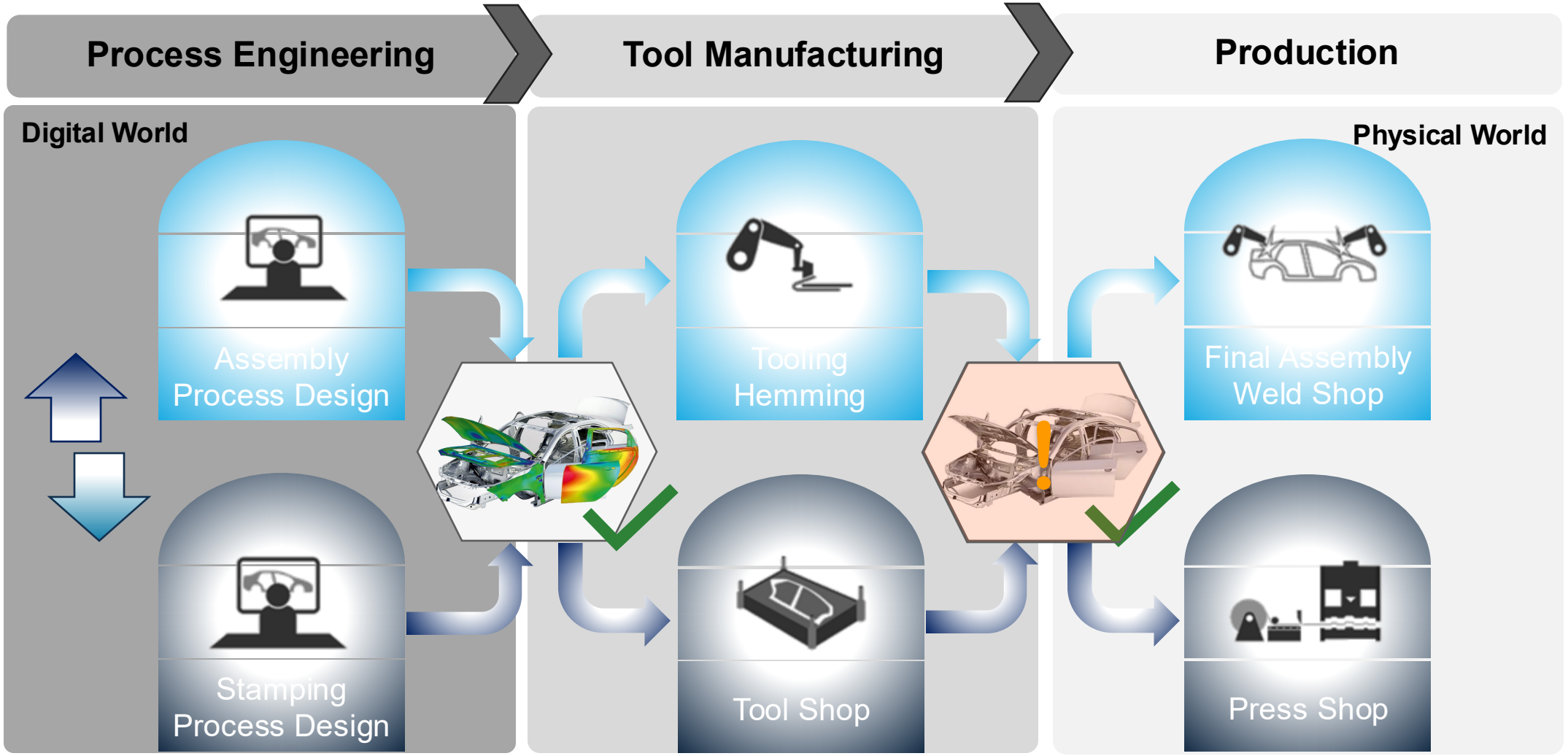
AutoForm Digital Process Twin

BiW Assembly Engineering

‘As-Is’ - Stamping & BiW assembly process



‘To Be’ - Integrated Stamping & BiW assembly process



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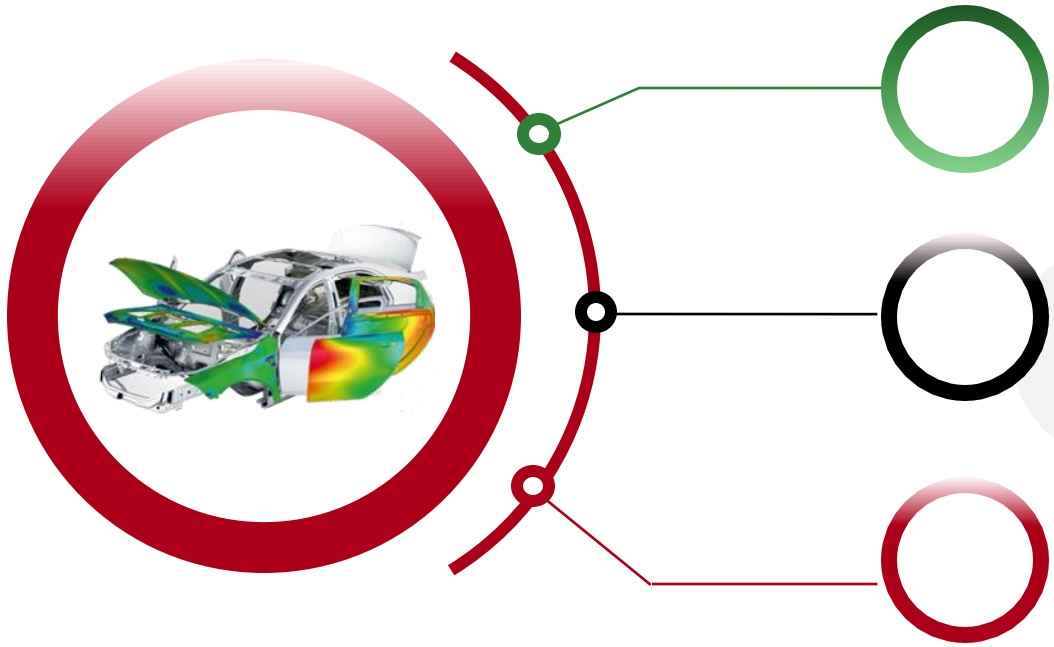
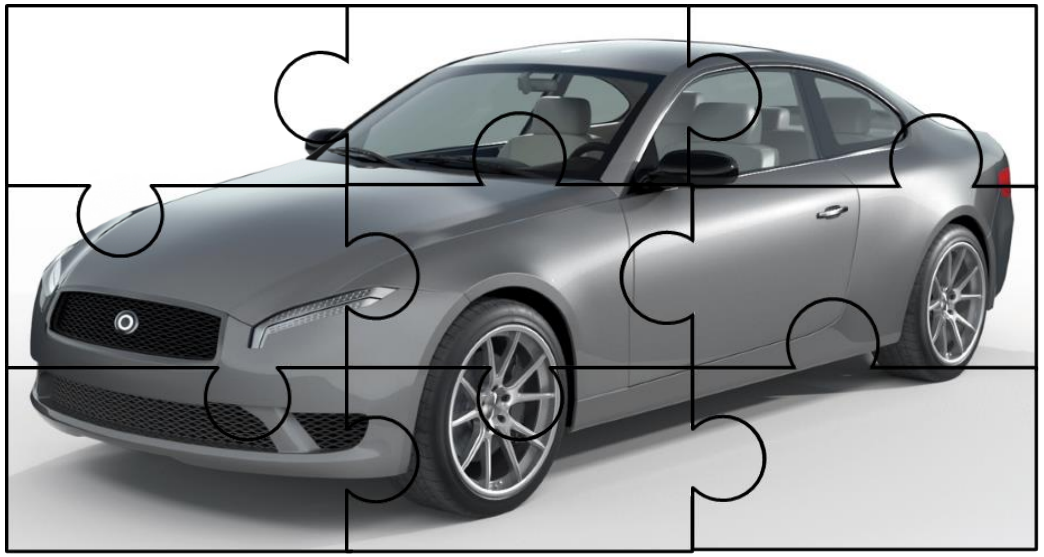


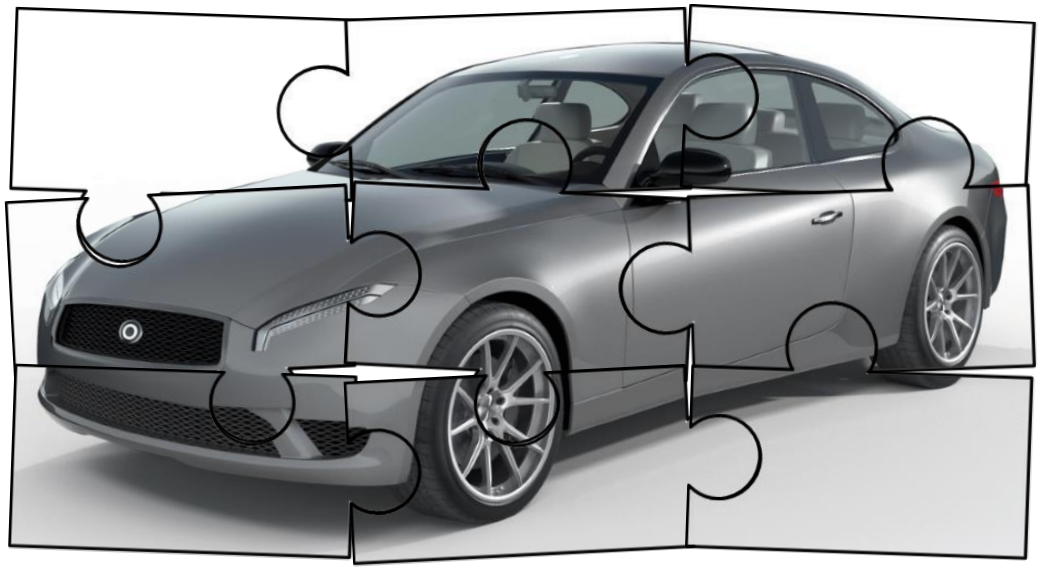
Industrial Applications & Advanced Methodologies

- *Impact of stamping results*
- *Advanced compensation strategy*
- *Stamping & Assembly robustness analysis*

Achieving dimensional & aesthetic compliance

“Green” stamped parts ? Assembly within tolerance





“Green” stamped parts Assembly within tolerance

#1 - Assembly analysis with stamping results

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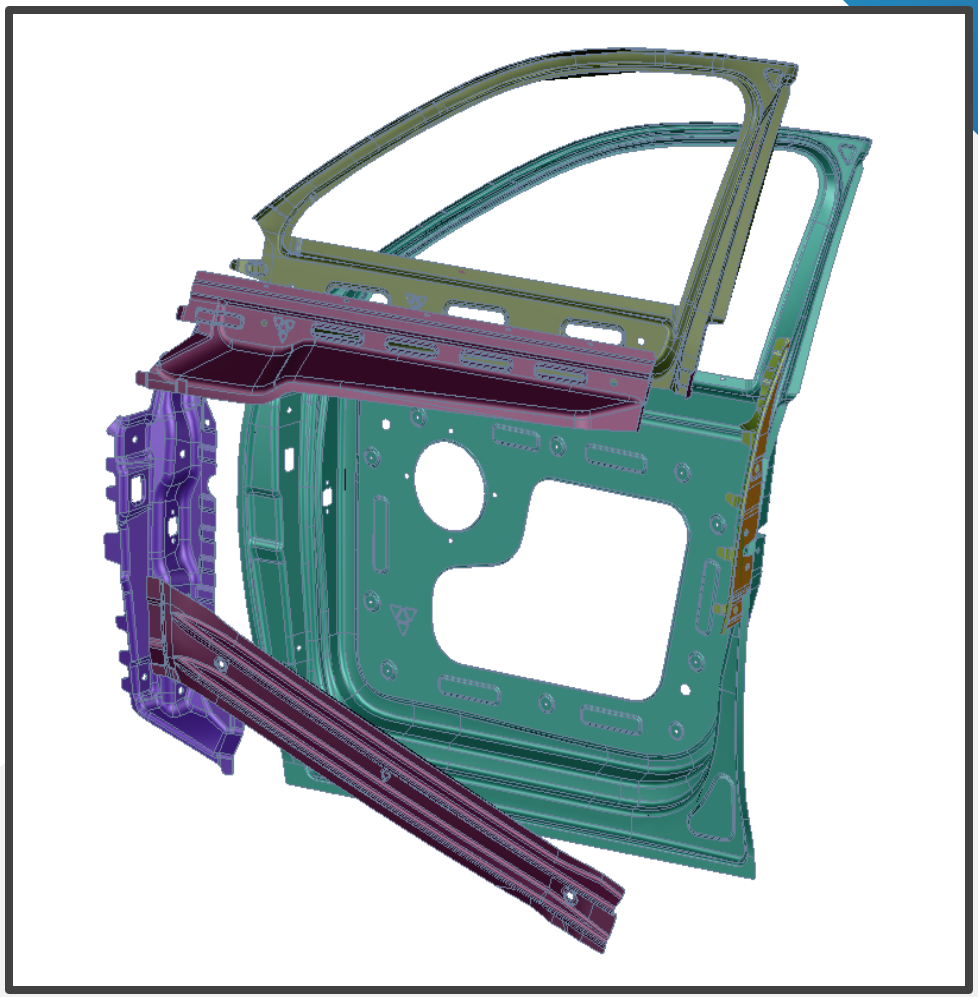
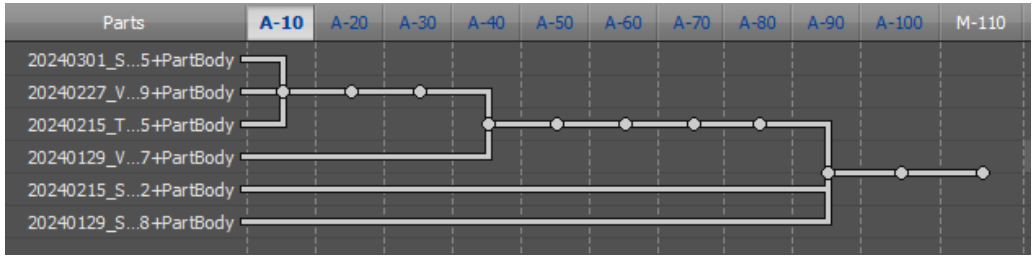
Can stamping results affect sub-assembly dimensional accuracy?

- Import of simulation results from stamping
- Impact of springback, thickness, stress, strain resulting from stamping process
- Greater accuracy in predicting deviations from nominal design
- Dimensionally compliant assembly / sub-assembly



Part 1: 1.50mm thick, CR300LA
Part 2: 1.20mm thick, CR1220Y1500T-MS
Part 3: 0.90mm thick, CR240BH
Part 4: 0.75mm thick, CR4-GI DX56D
Part 5: 0.80mm thick, CR4-GI DX56D
Part 6: 0.70mm thick, CR4-GI DX56D

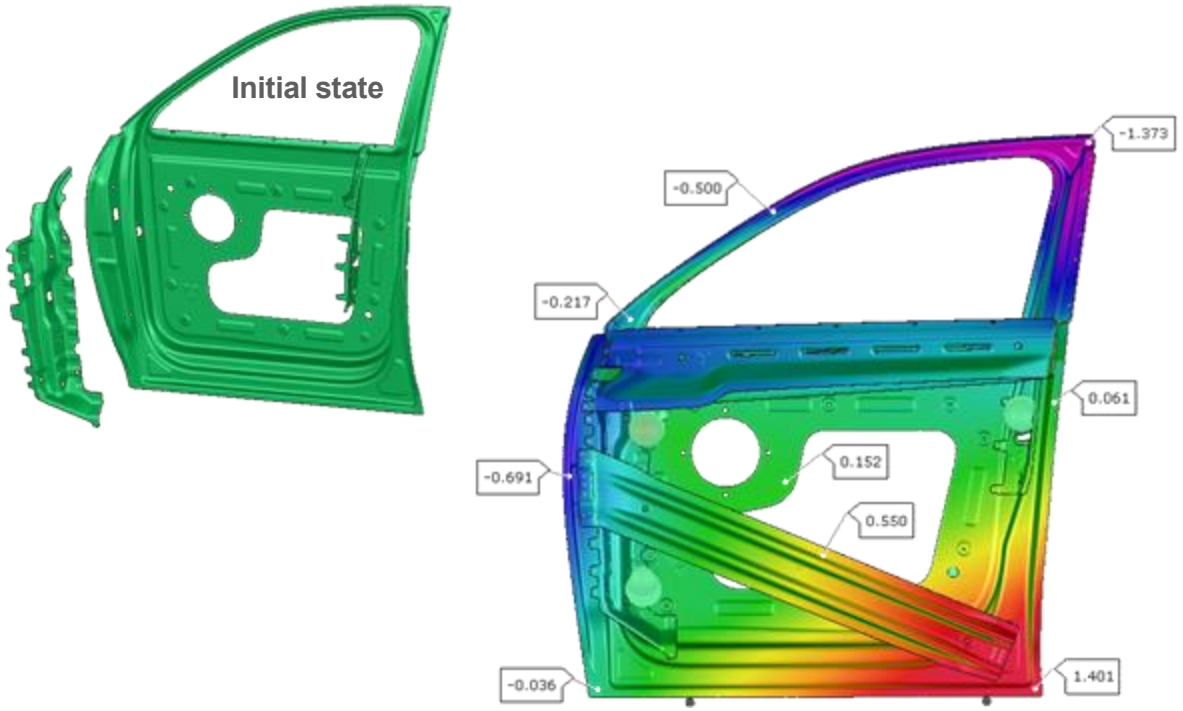
Door inner assembly



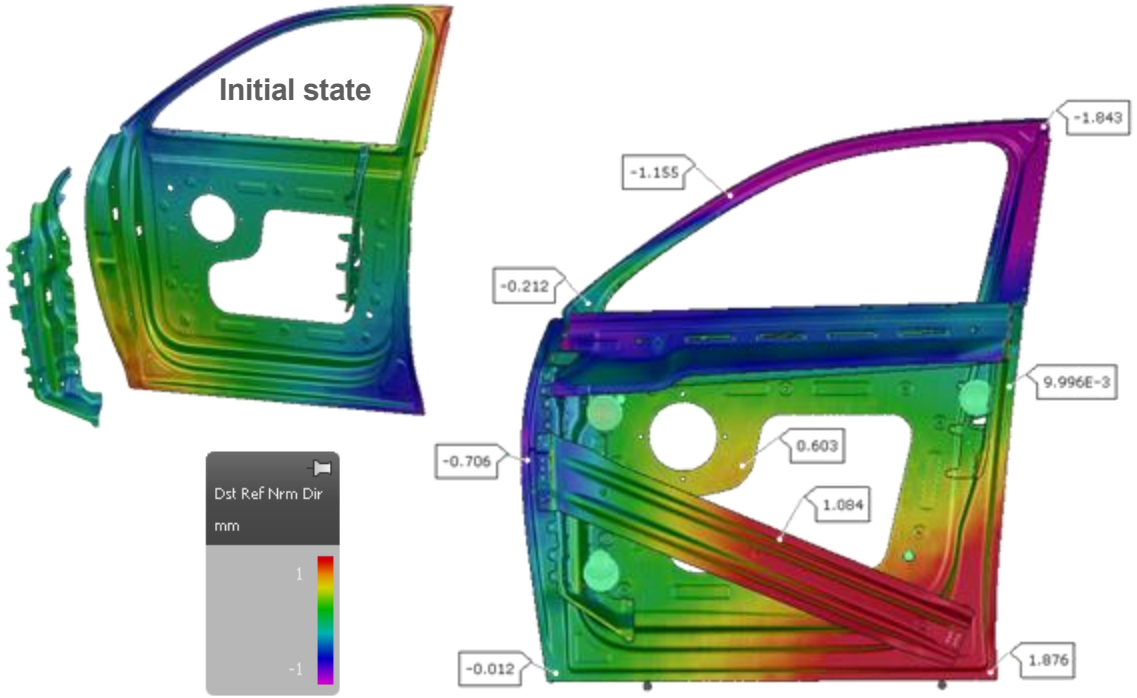
Process Description & Results:

- 10 assembly operations
- 1 measurement operation
- 3 geo-stations (A-10, A40, A-90)

- Conspicuous deviation from reference with nominal geometries
- Even worst deviation with stamping results

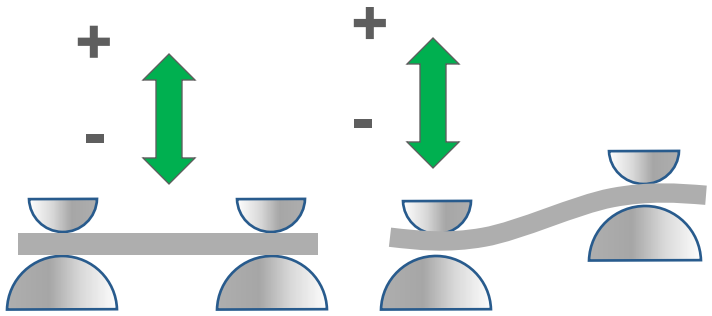


#1 – Deviation to reference (Measurement OP) - with nominal parts

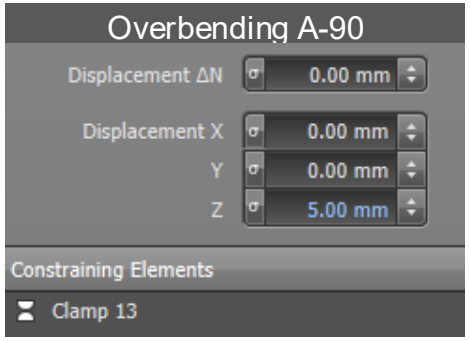


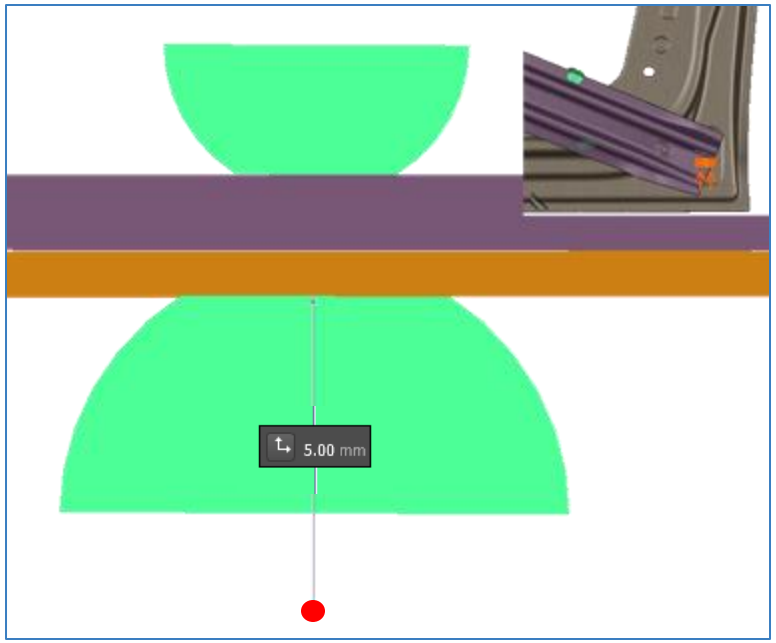
#2 – Deviation to reference (Measurement OP) - with stamping results

Door inner assembly: Virtual shimming strategy



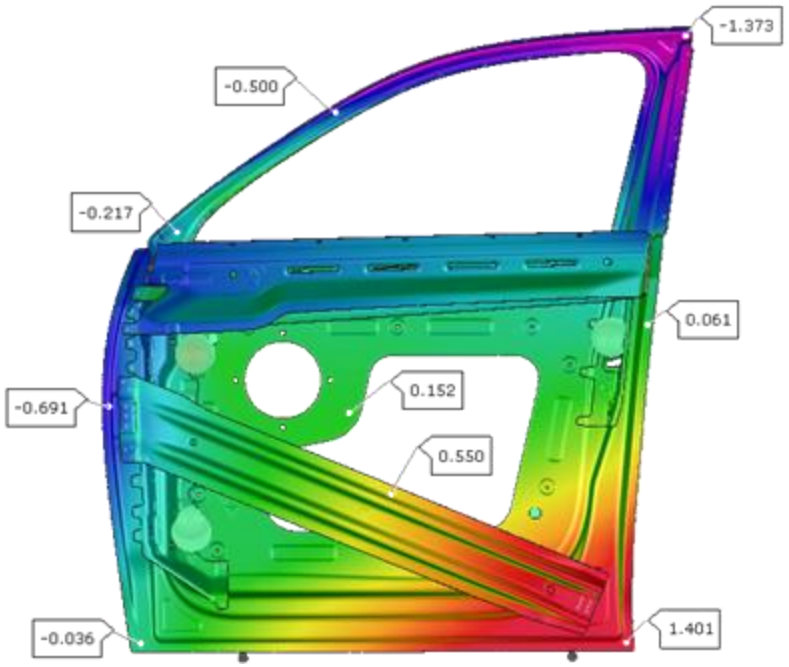
- Apply shimming/overbending of clamps, offset of supports
- A-10 & A-90 operations: impact of door hinge & window frame reinforcements
- Shimming / overbending of clamps, offset of supports – to counterbalance the joining-induced distortion
- Virtual evaluation / finalization of common counter-measures applied at tryout



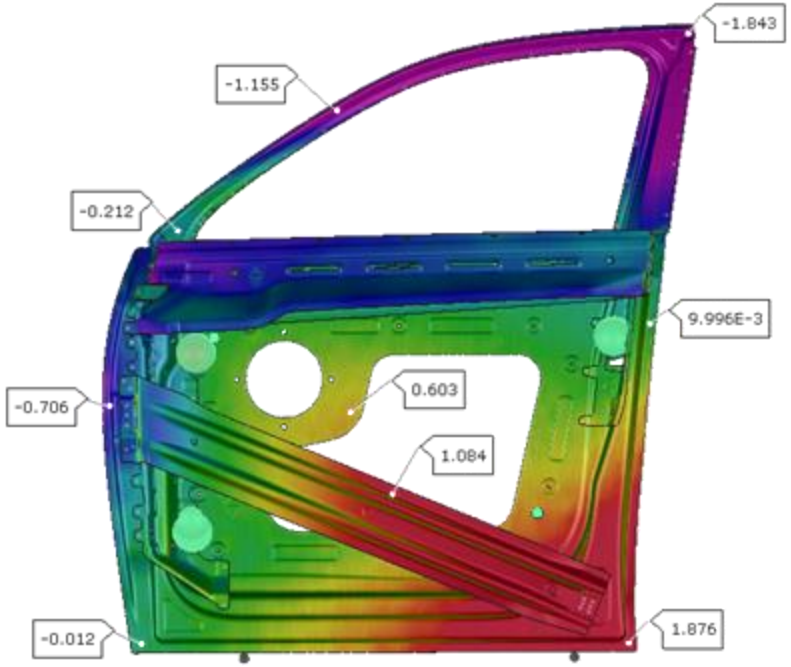


Door inner assembly: Final results

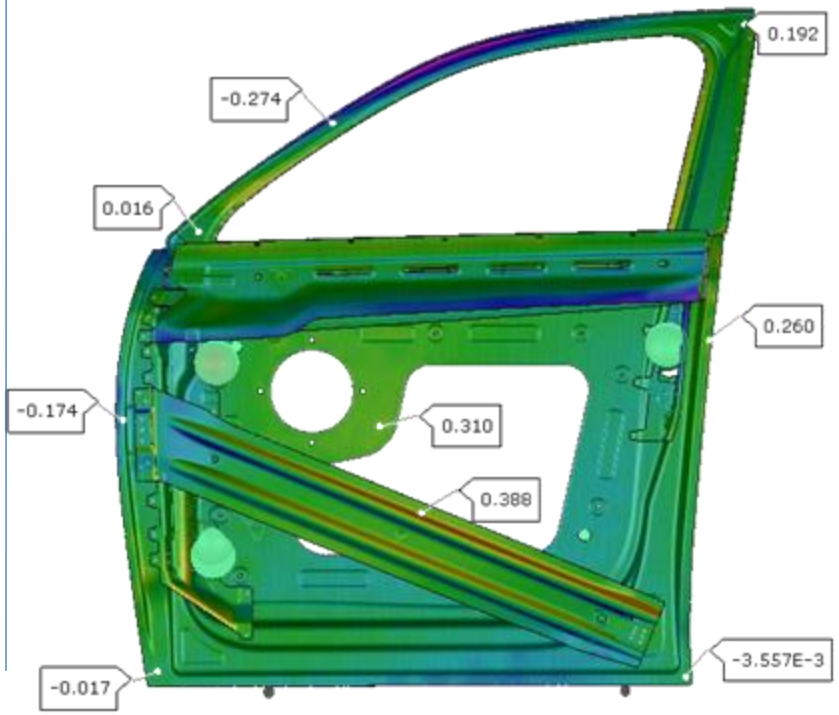
- Door inner sub-assembly is represented in car position and according to RPS conditions
- Deviation to nominal are shown on the final Measurement operation (checking fixture)
- Early evaluation of deviations (from CAD-0 or stamping results) before pre-series production
- Efficient virtual shimming strategy to reach sub-assembly dimensional accuracy



#1 – Based on nominal parts



#2 – With stamping results

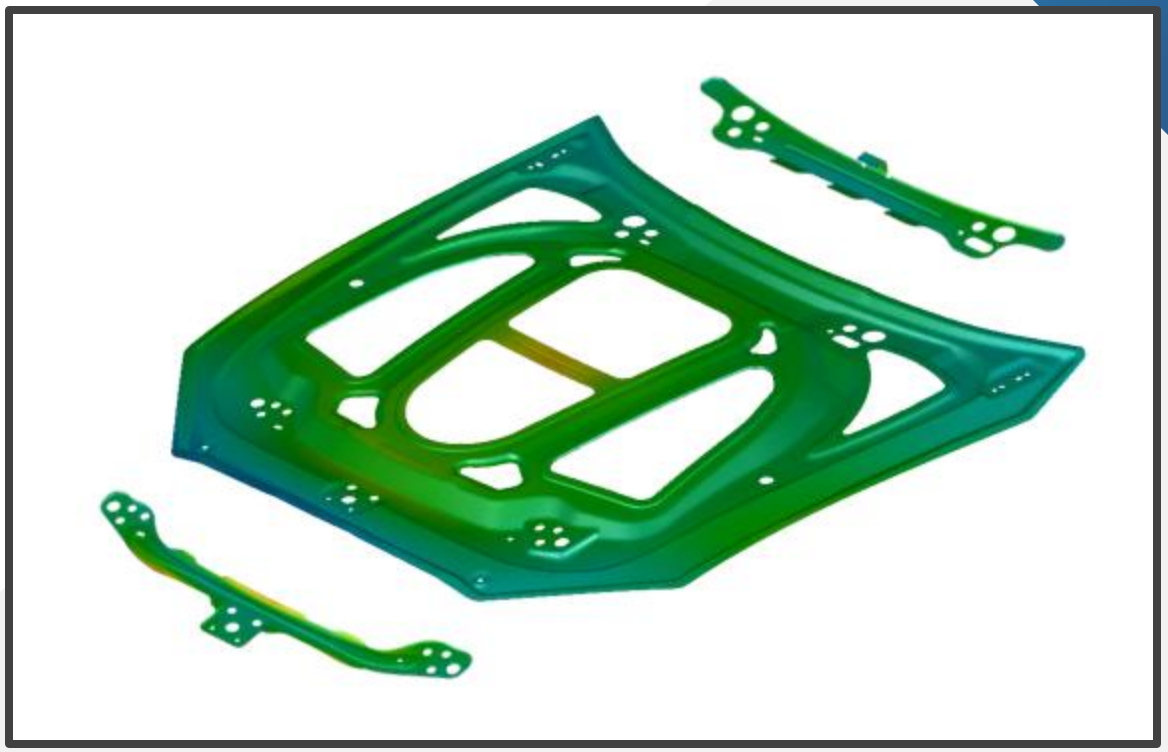


#3 – With stamping results + shimming correction

#2 - Assembly compensation strategy

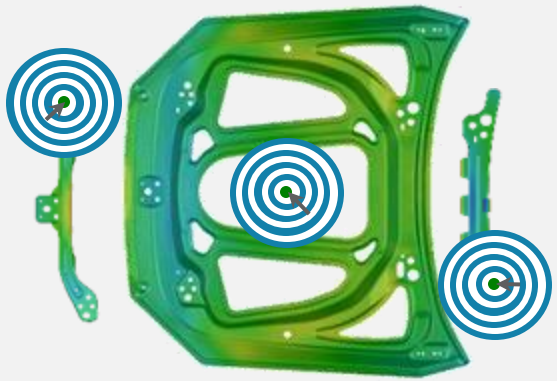
What other options than joining sequence and/or shimming are available to get the sub-assembly within tolerance?

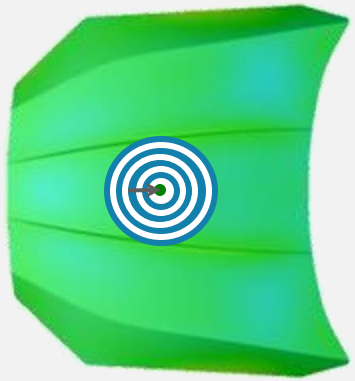
- Identify most leading / influential parts
- Define new target compliant with sub-assembly
- Apply Assembly-specific compensation strategy

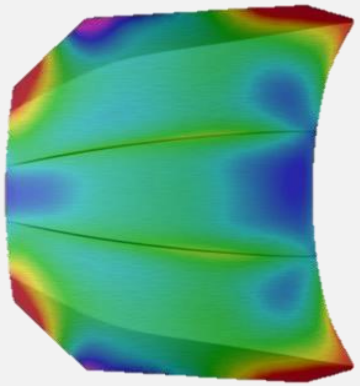


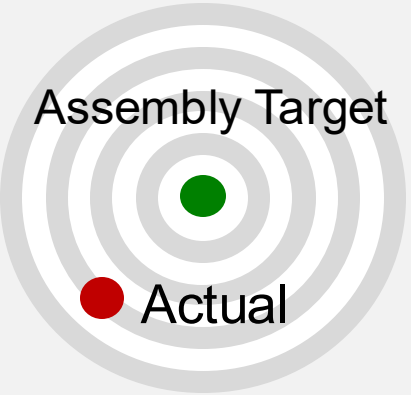
Assembly compensation strategy: Concept

BEFORE Part sub-system optimization









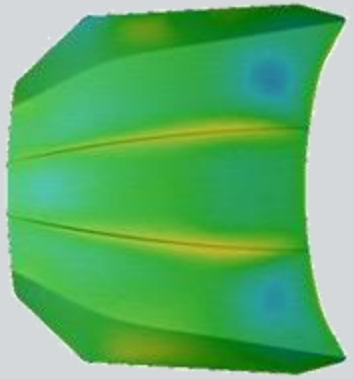
AFTER Assembly system optimization

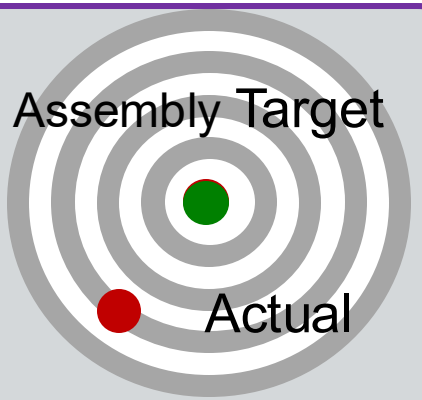
Solution: Assembly-specific Compensation Strategy

Which alternative to get the assembly in-tolerance?

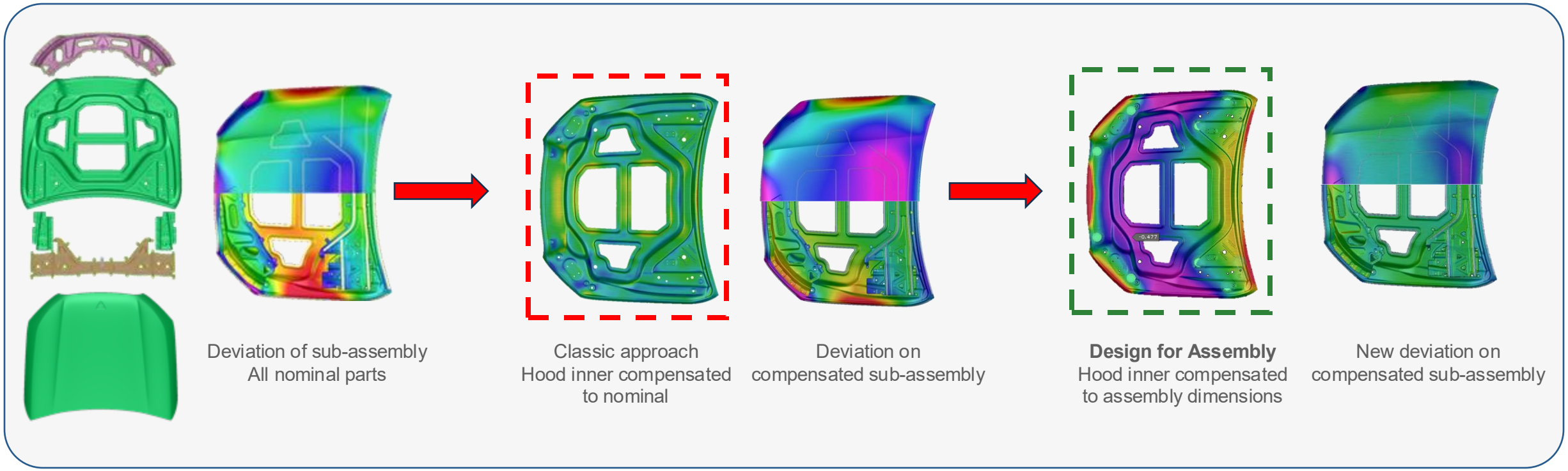
A strategy based on distortion resulting from the assembly sequence

This is a Design For Assembly (DFA) approach





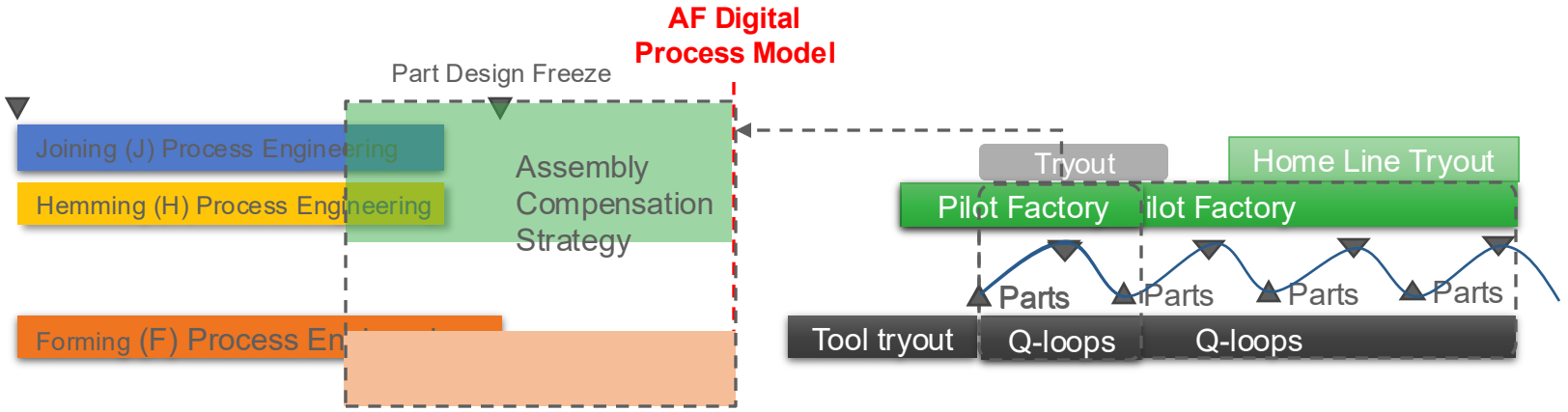
Assembly compensation strategy: Example



- Implementation of an Assembly-specific / Design for Assembly approach
- A key-feature that calculates the hood inner compensated geometry to minimize the deviation, and get the sub-assembly within tolerance

Assembly compensation strategy: Implementation

At which stage of a vehicle program?

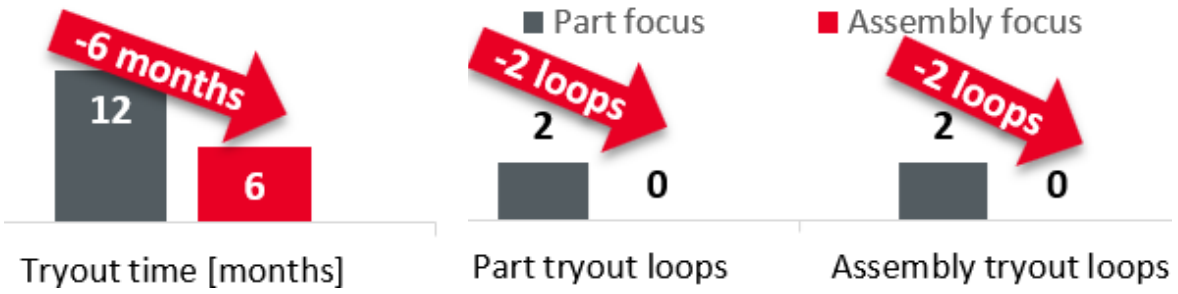


Benefits

- Optimize component & assembly design
- Avoid assembly correction at press shop
- Reduce Q-loops & pre-production build efforts

- Reduce number of pre-series / prototype assemblies
- Digitalize your BiW supply chain

Example of quantified savings obtained at a premium car manufacturer



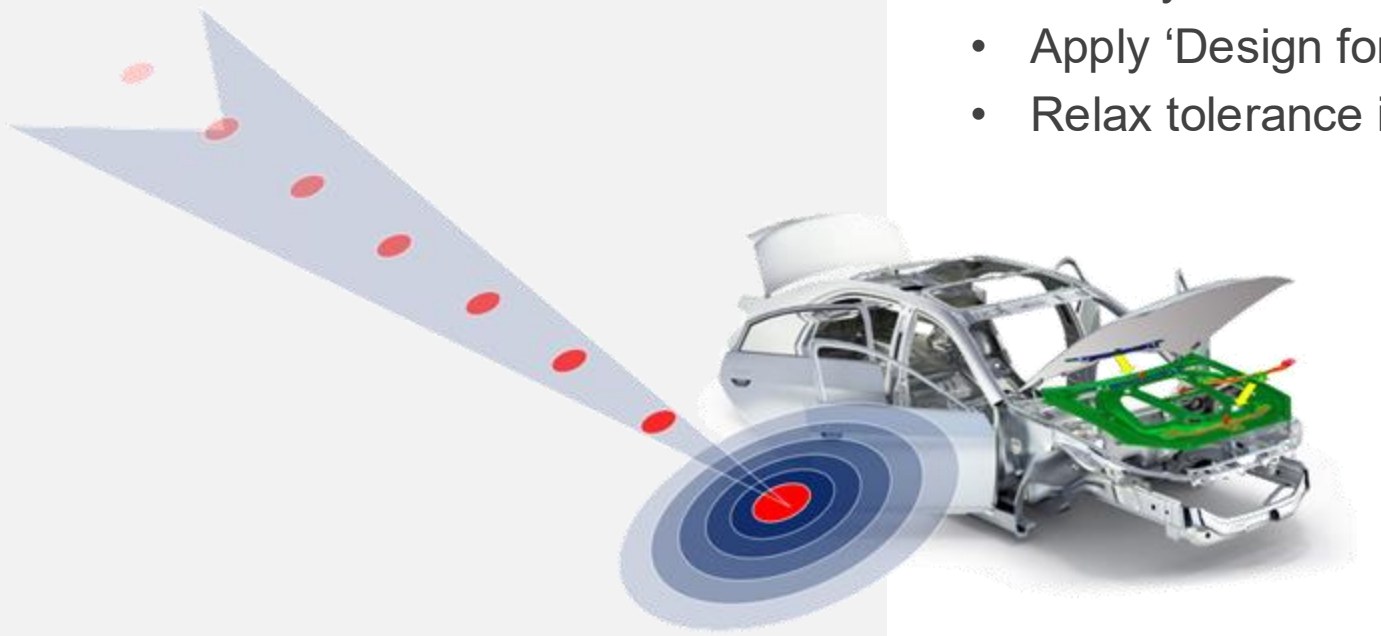
Fuel for Thought

Try to compensate single parts?

- Which individual part to compensate?
- By how much should we compensate?
- Lots of effort & cost to reach tolerance for each single part

Focus on a ‘target geometry for assembly’?

- Identify the most leading part(s)
- Apply ‘Design for Assembly’ approach
- Relax tolerance in some areas



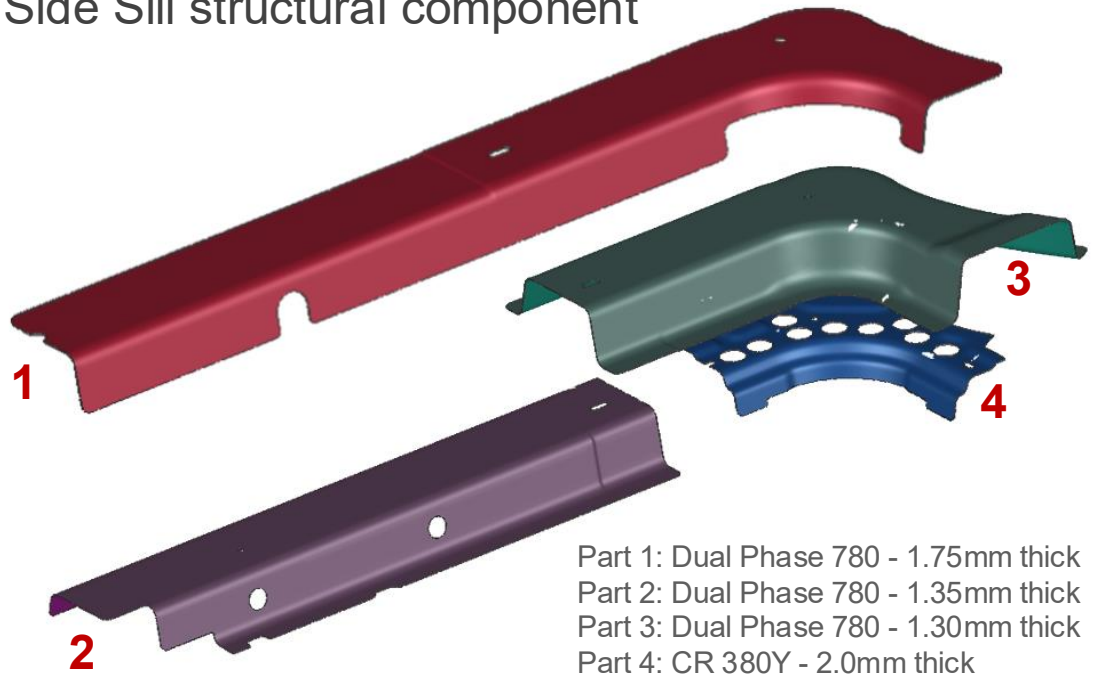
#3 - BiW assembly process variability analysis

Can process variability observed on stamped parts affect the final sub-assembly?

- ‘Process Variability’ means impact of process parameters that you cannot totally control

- **Process variability in stamping**
  - Blank thickness
  - Material parameters (Re, Rm, …)
  - Lubrication
  - Force on blank holder / binder
  - Blank position
  - …

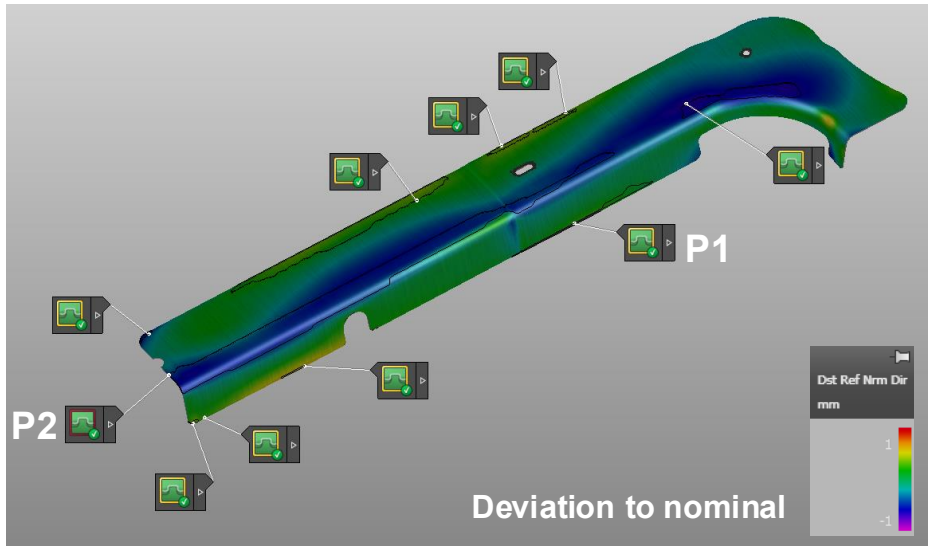
Side Sill structural component



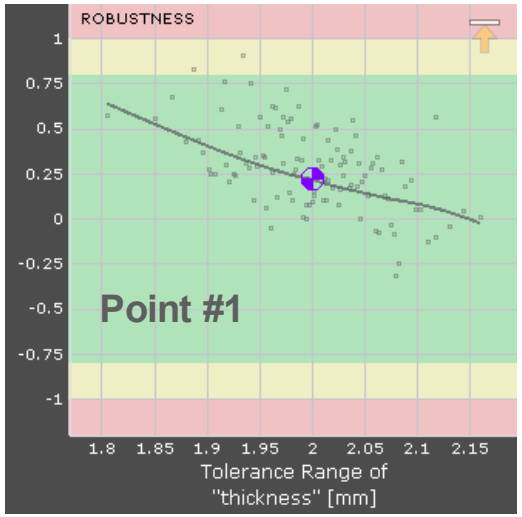
Part 1: Dual Phase 780 - 1.75mm thick
Part 2: Dual Phase 780 - 1.35mm thick
Part 3: Dual Phase 780 - 1.30mm thick
Part 4: CR 380Y - 2.0mm thick

Step #1: Stamping process variability

Side Sill example: Impact of process variability on springback outcomes

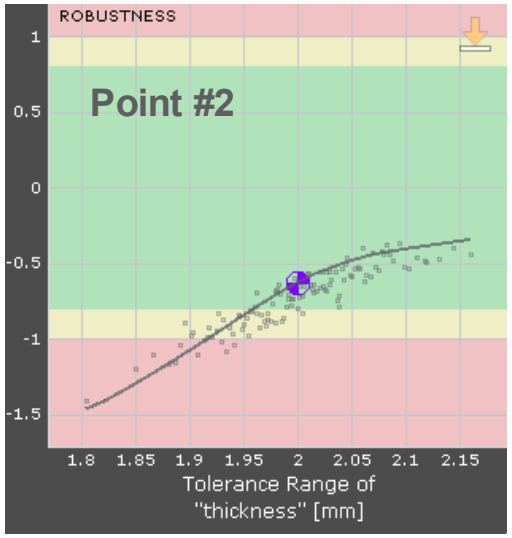


Property	Nominal Value	Range
Yield stress	403 Mpa	+/- 10%
Tensile strength	521 Mpa	+/- 10%
Blank thickness	2mm	+/-10%
Lubrication	1 g/m^2	+/-10%
Binder force	2700 kN	+/-10%
X-Position		+/-1mm
Y-Position		+/-1mm



For all points
- Based on nominal values, the part is in-tolerance

At Point #1
- All outcomes in ‘safe’ area



At Point #2
- Few outcomes in ‘red zone’
- Process is NOT sufficiently robust in this area

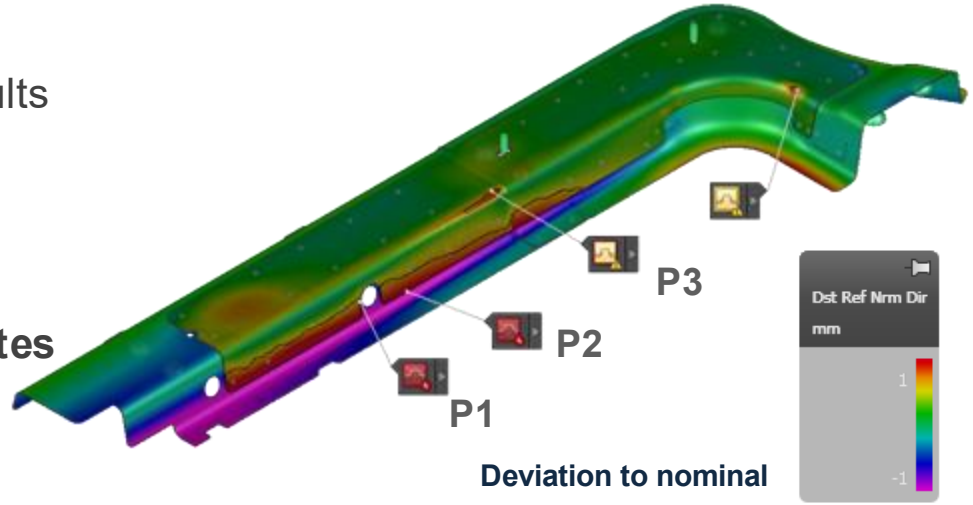
Step #2: Assembly process variability

Side Sill example: impact of stamping process variability on sub-assembly

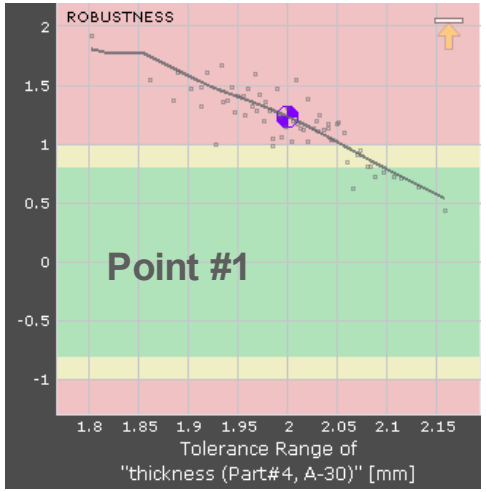
Parts/Subassemblies	Start Geometry	Deformation	Simulated Result
Part4	CAD-0	Measured	None
Part3	CAD-0	Measured	None
Part2	CAD-0	Measured	None
Part1	Simulated	Robustness	Robustness

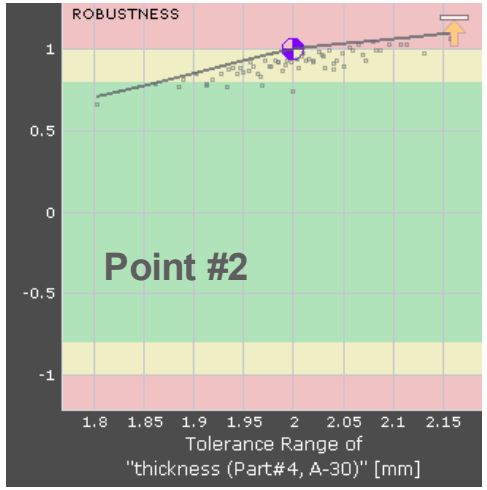
Name	Min	Max
A-30 - Part1		
force	2430 kN	2970 kN
lubeAmount	0.8	1.2
Mat01_RValue	0.7928	1.189
Mat01_yieldStress	362.7 MPa	443.3 MPa
Mat01_tensileStrength	469.2 MPa	573.5 MPa
thickness	1.8 mm	2.2 mm
xPos	-1 mm	1 mm
yPos	-1 mm	1 mm

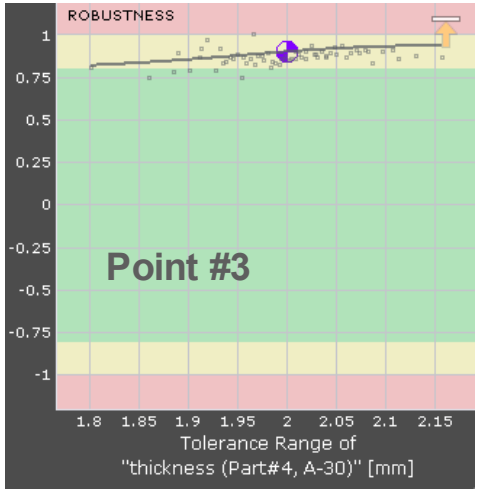
- Assembly simulation uses stamping results (incl. process variability)
- All points exhibit target in ‘unsafe’ area.
- **Assembly robustness analysis indicates that the process is NOT robust**
- Blank thickness variability is most critical

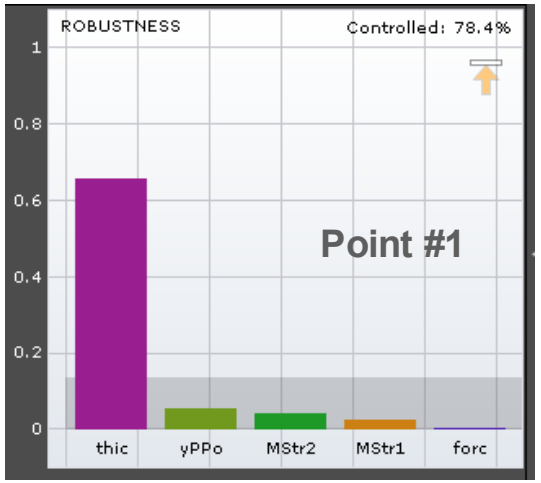


Deviation to nominal









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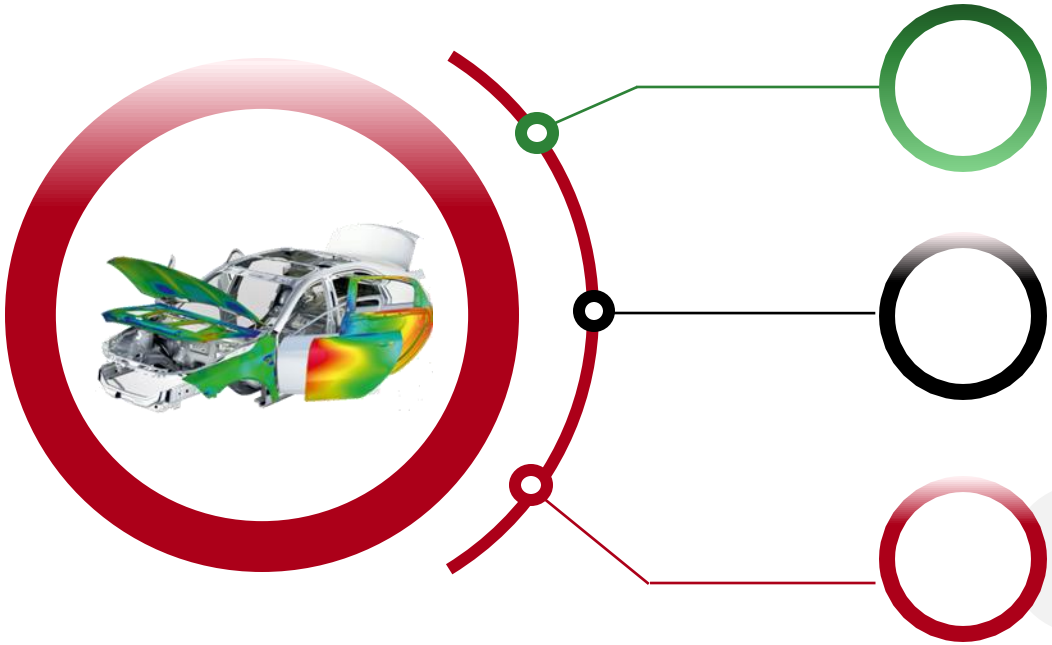
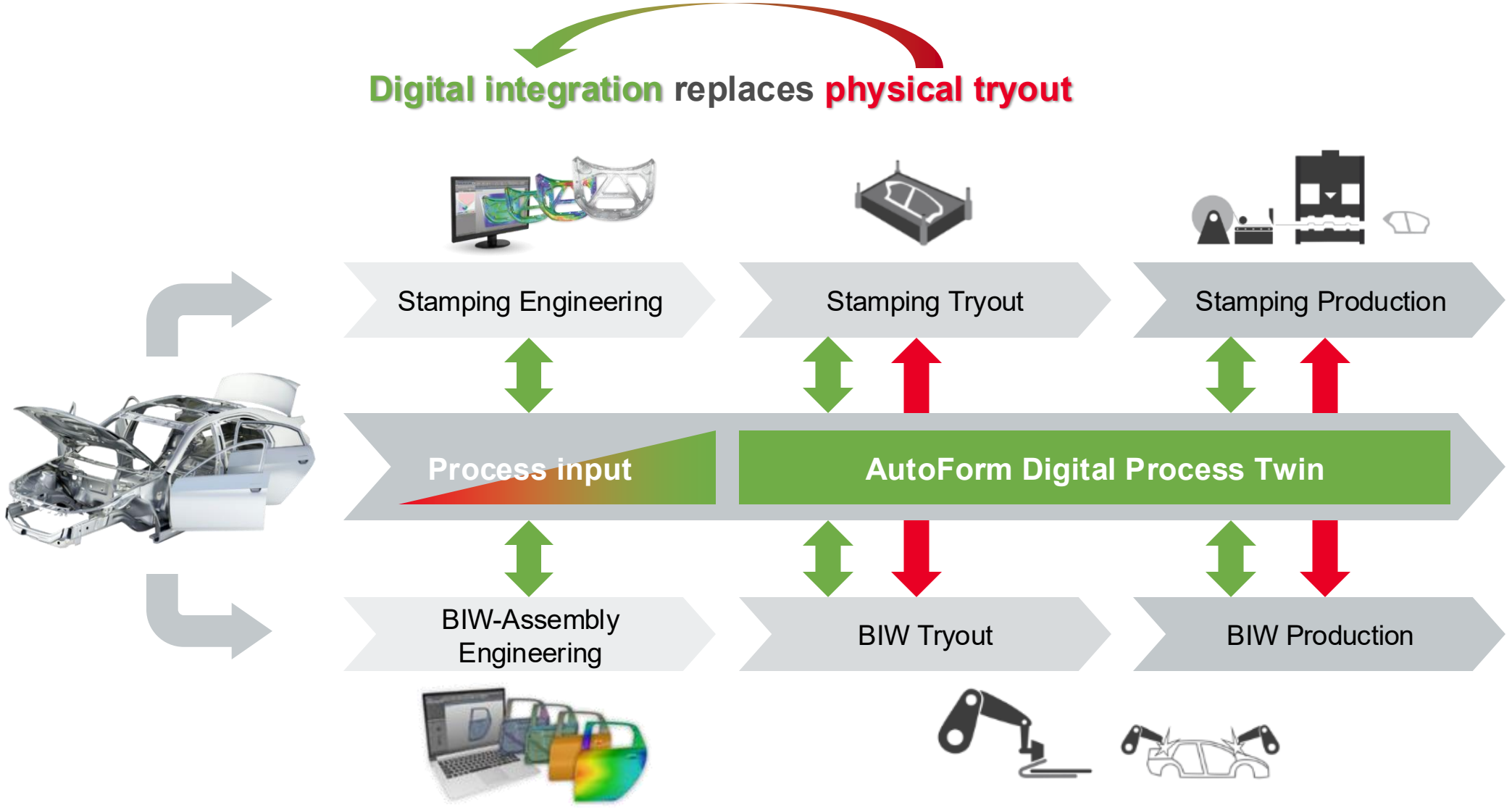


Conclusions & Takeaways

Seamless digitalization of manufacturing processes



Key Takeaways

Full digitalization approach for Stamping & BiW Engineering

Foster collaboration between stamping & BiW engineering

From process feasibility all the way through full process validation stage

Frontload Assembly Process Simulation

- Identify issues when cost of changes is low
- Benefit from key-features & methodologies
- Achieve robust part & sub-assembly production
- Significant cost savings in tryouts with fewer quality loops

Engage OEMs & supply chain towards full BiW digital validation & continuity

Increased benefits when same methodology is shared for digital validation & data continuity

Q&A Session

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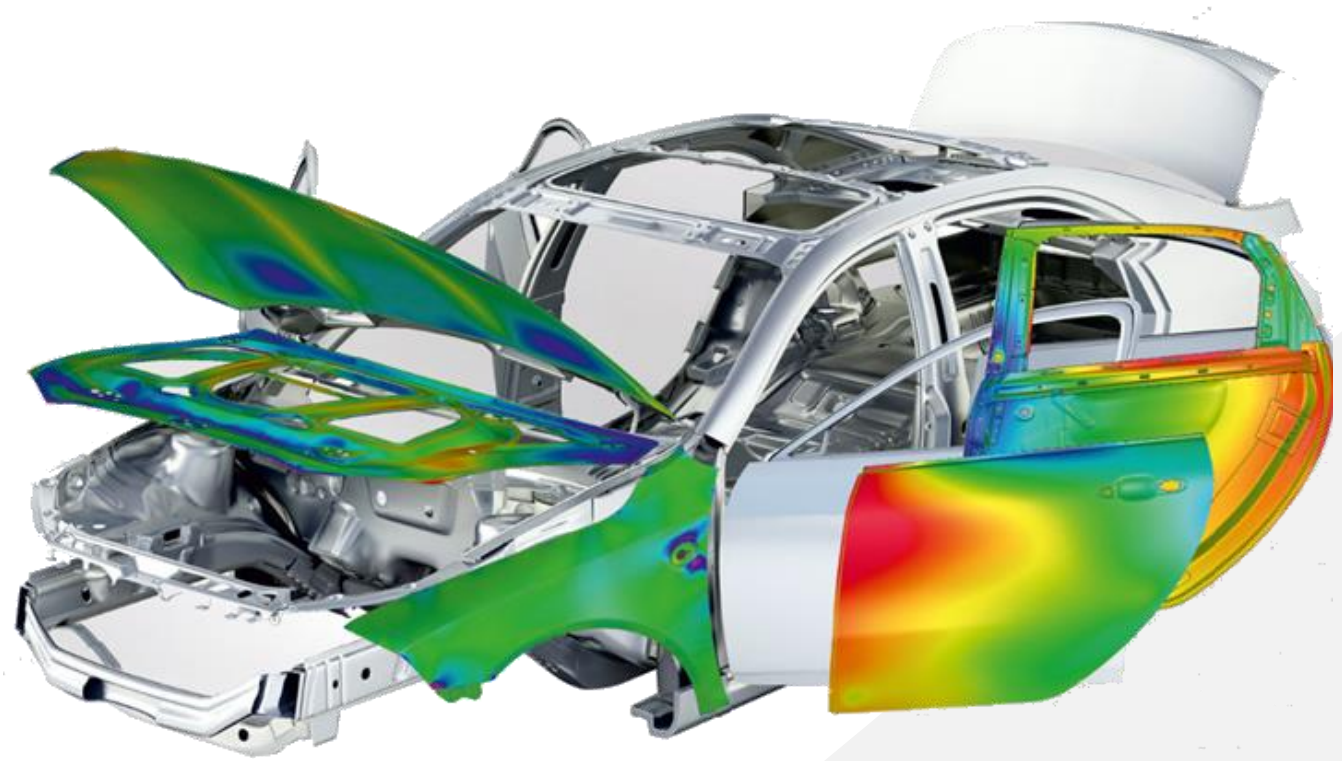

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AUTOFORM
Forming Reality