BMW GROUP

SIMULATION OF SHEET METAL FORMING.

CURRENT DEVELOPMENTS.

TP-111

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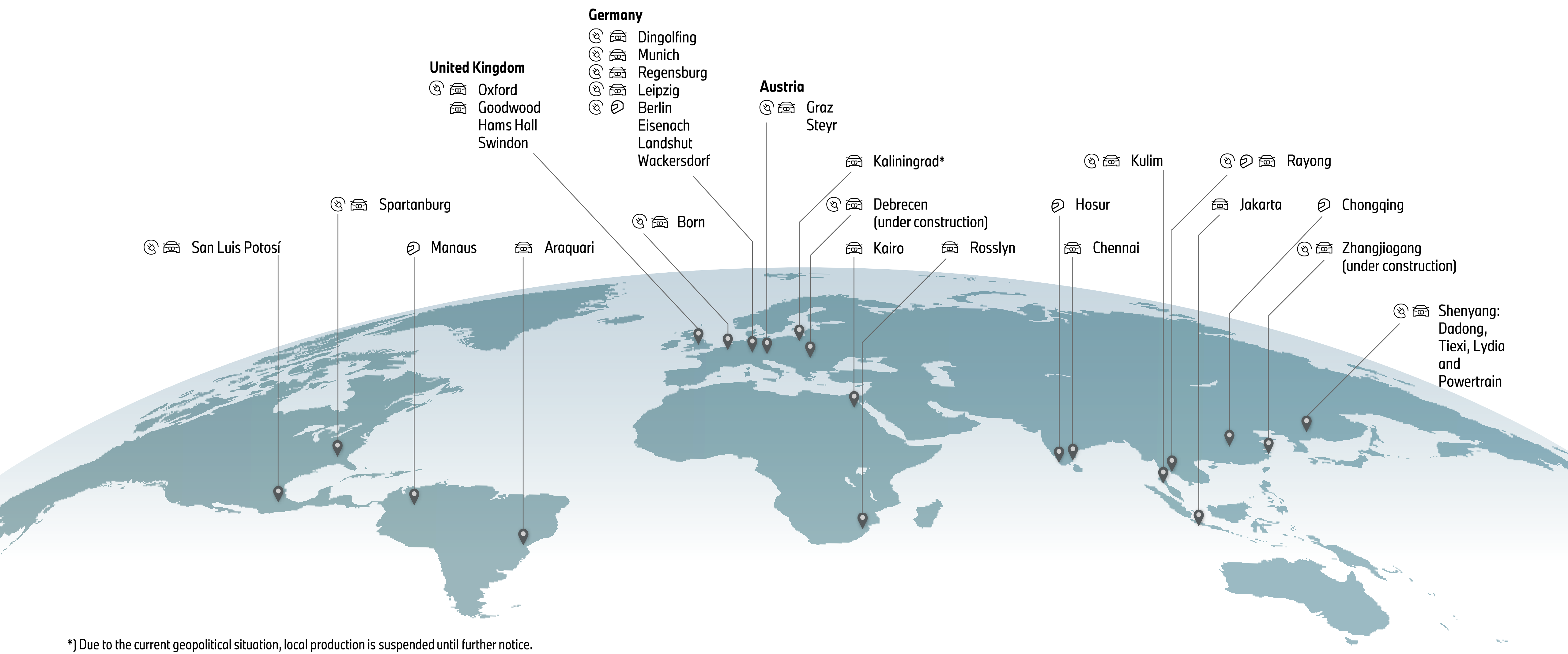
INTRODUCTION - INTERNATIONAL BMW GROUP PRODUCTION NETWORK. MORE THAN 30 PRODUCTION SITES ALL OVER THE WORLD.

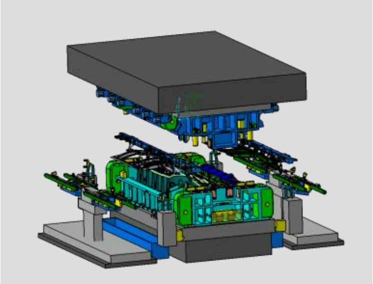


*) Due to the current geopolitical situation, local production is suspended until further notice.

INTRODUCTION.
FROM THE DESIGN TO THE ENGINEERING TO A DEEP DRAWING TOOL.

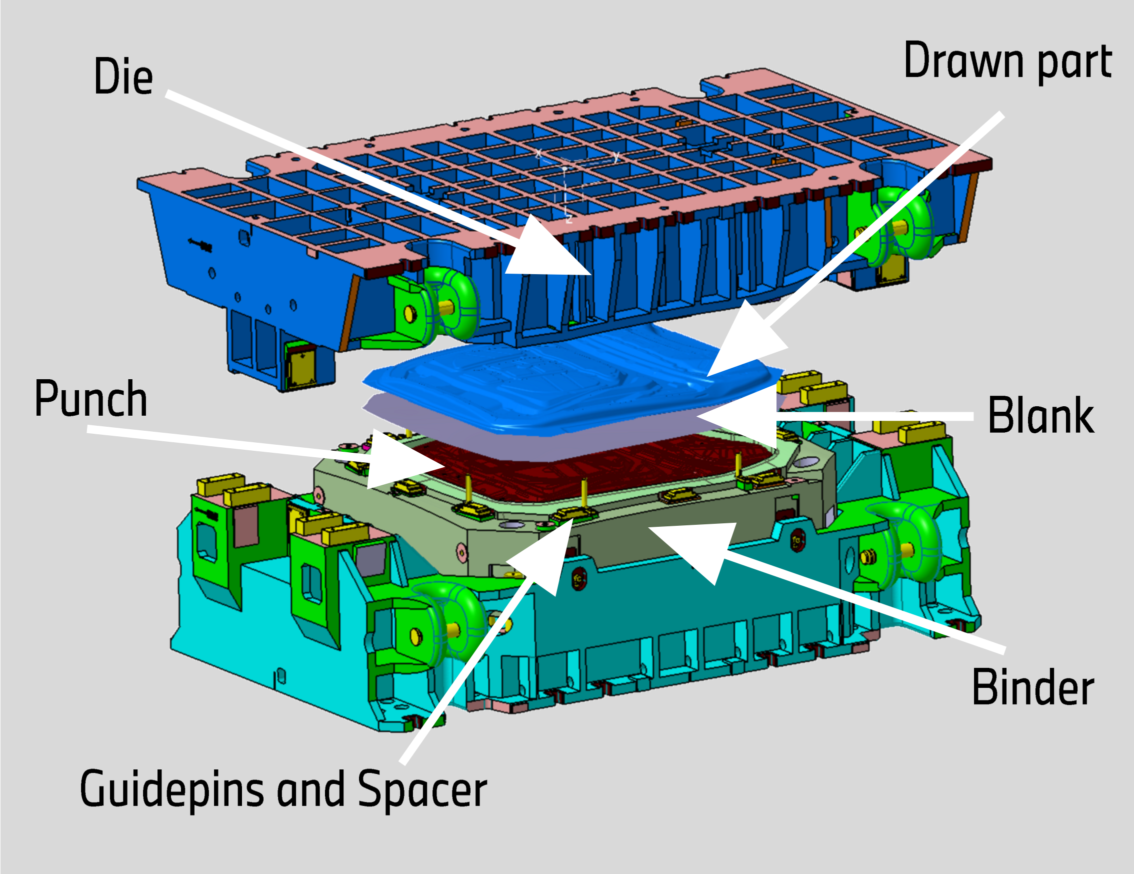
– Cardesign.

– Engineering.



– Production.

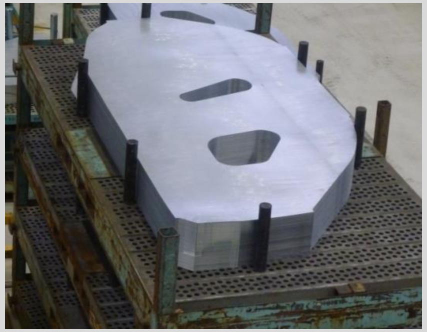
- Exemplary setup of a forming tool of a hood-inner.



INTRODUCTION.

- Part production at the press shop.
  - Raw material.

  - Coil-Cut.



  - Press shop.

  - Deep drawing tool.

- Assembly of the single parts to a body in white.

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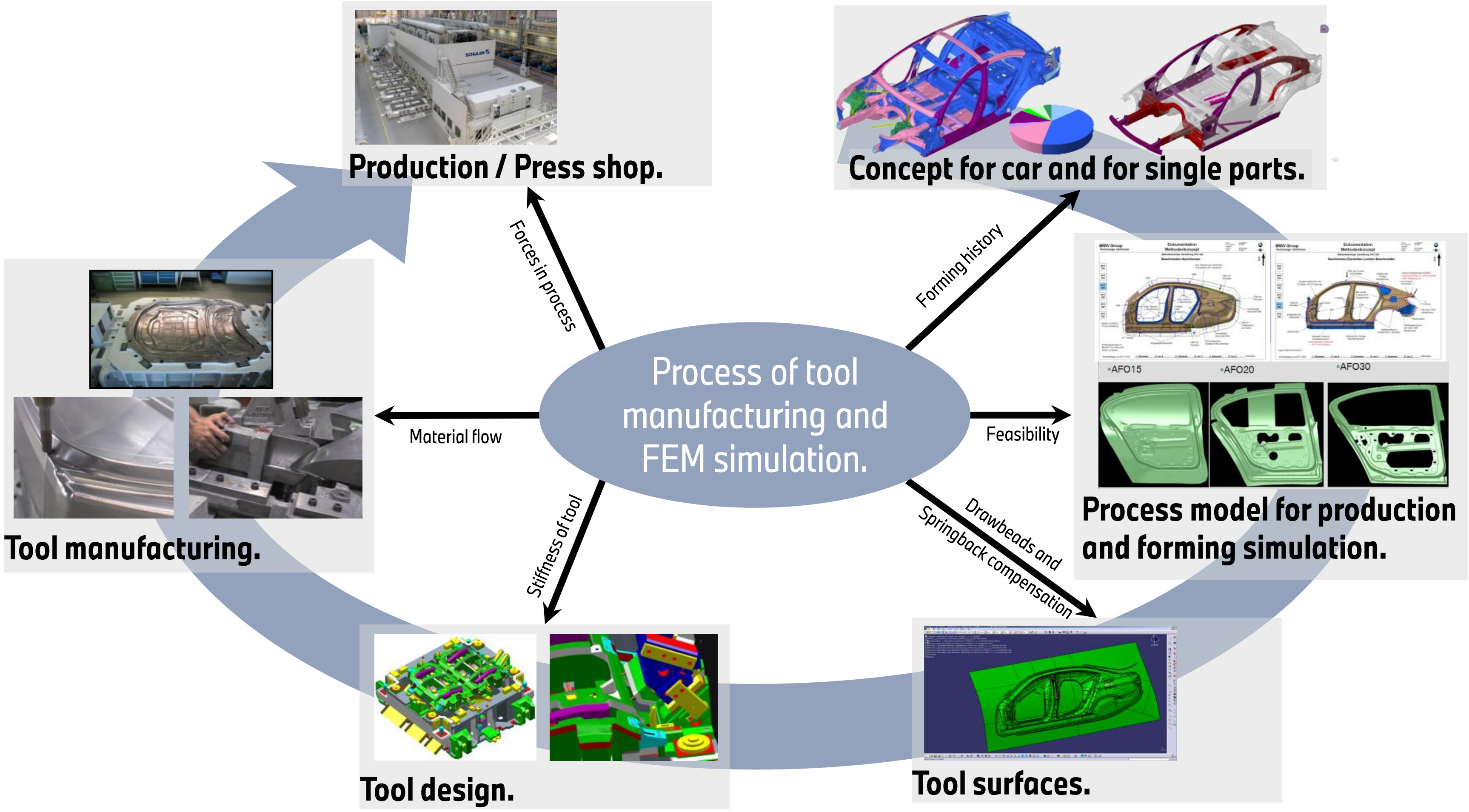
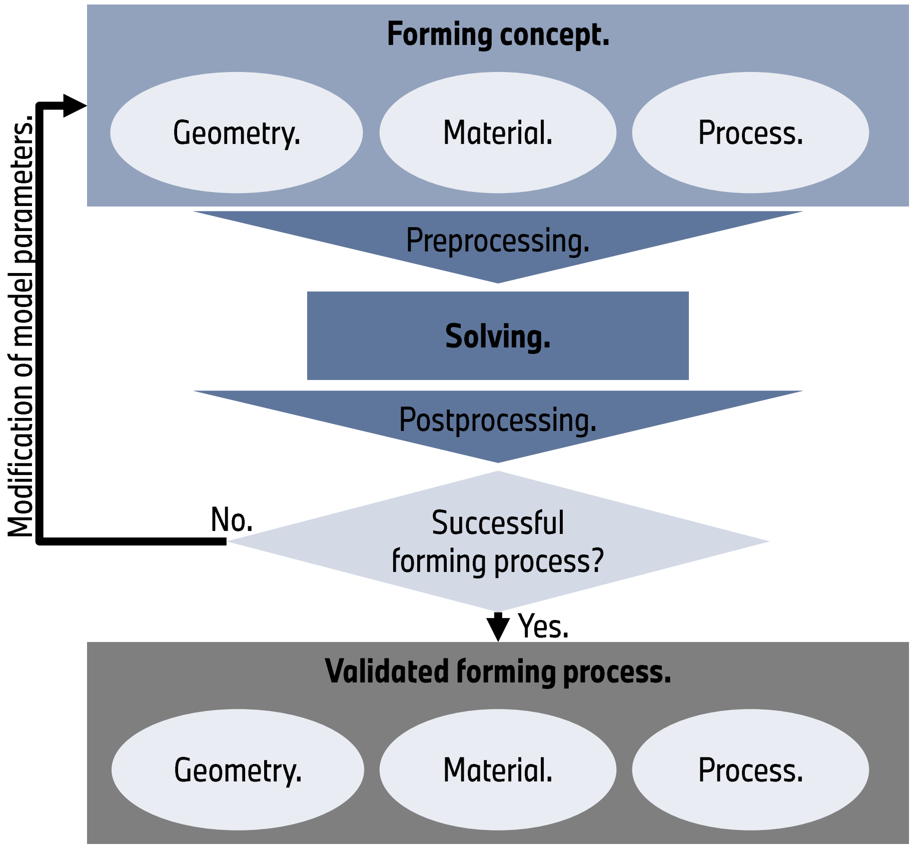
FORMING SIMULATION AT BMW – STATE OF THE ART.
SIMULATION IN THE TOOL DEVELOPMENT PROCESS.

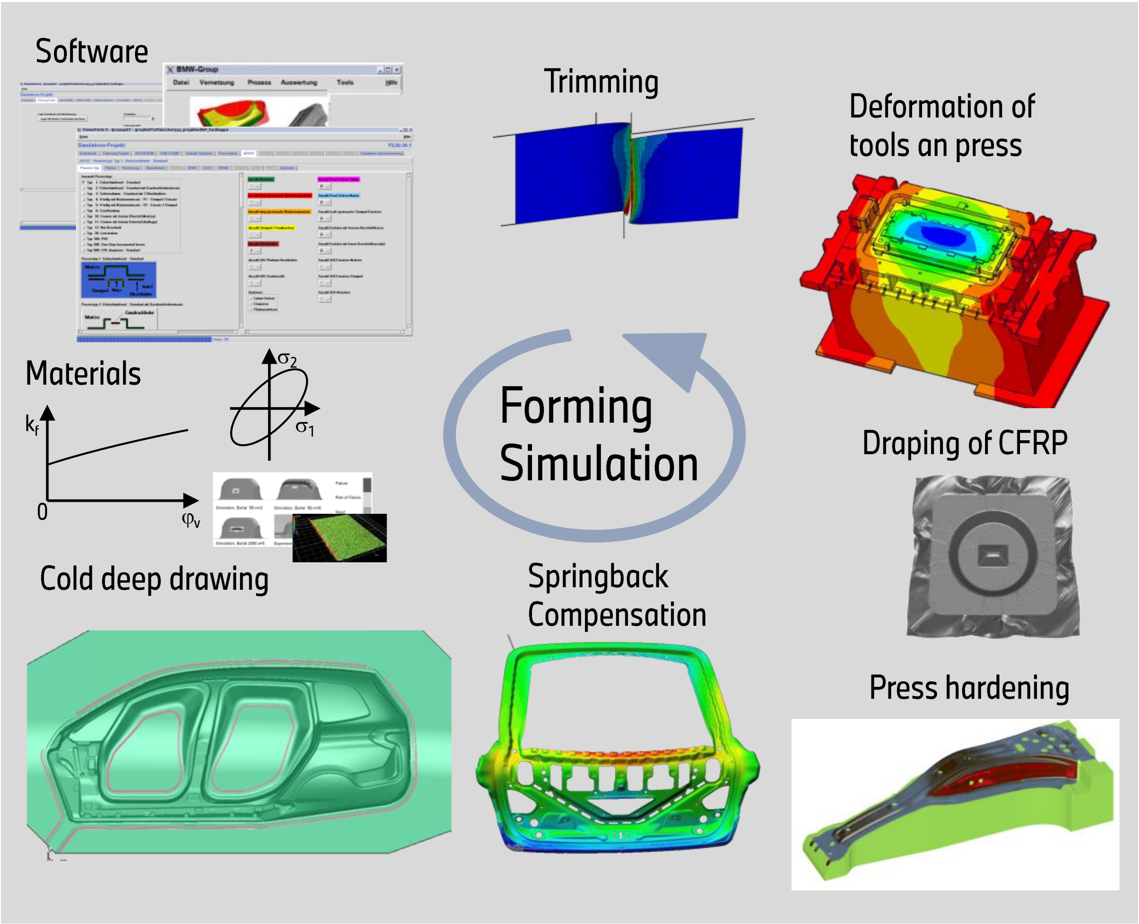


FORMING SIMULATION AT BMW – STATE OF THE ART.

- Modular setup of the processes.



- Application of forming simulation.



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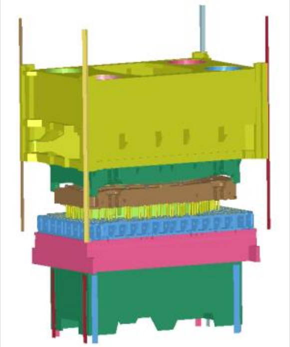
CURRENT DEVELOPMENTS.
LIMITATIONS OF THE RIGID-TOOL-ASSUMPTION.

- State of the art sheet metal forming simulation in the series engineering has a lot of assumptions.
- One assumption is that the tools are absolutely rigid.
- Several strategies for enhancements of elastic tools have been investigated – Full approach vs. local approach.
- Application of an elastic blankholder has increased the accuracy of the prediction for the blank [20].

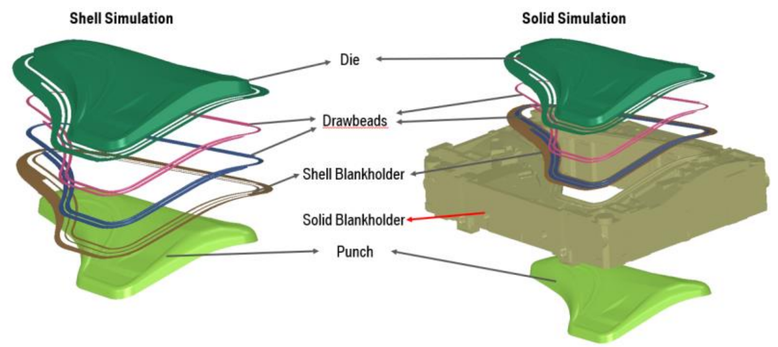
- Full approach vs. local approach on a first prototype.

Whole press and tool



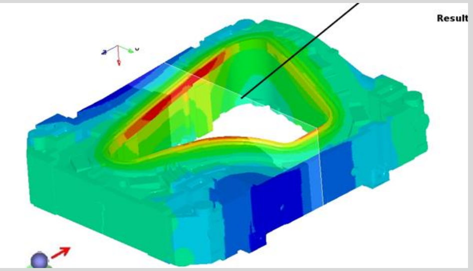
Rigid-tools

Enhancement of the blankholder

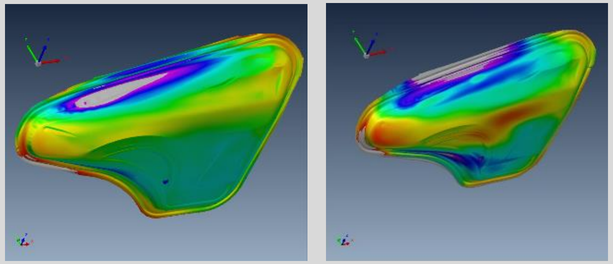


- Tool stiffens and influence on springback.

Tool deviation of blankholder under force load



Influence on springback is depending of the BLH modelling

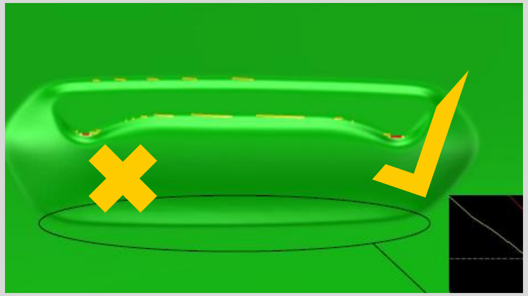


CURRENT DEVELOPMENTS.
DOOR HANDLE AND SHARP RADII.

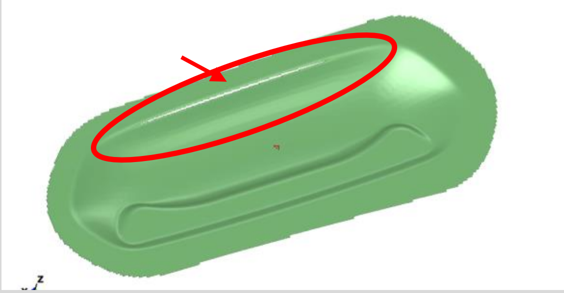
- FLD is state of the art for failure prediction in sheet metal forming and has limited capabilities.
- Application of fracture models like GISSMO or DIEM into the standard engineering process is ongoing.
- Shell-Elements have different limitations; even on sharp radii. Application of Solid-Elements is a possible next step to increase the accuracy of prediction.
- New shell implementations will be investigated to solve this problem as well (e.g. IGF-Forschungsvorhaben „3D-Blechmodellierung 2“) [18].

- Application to a door prototype – FLD prediction.

Shell – Blank FLD plot

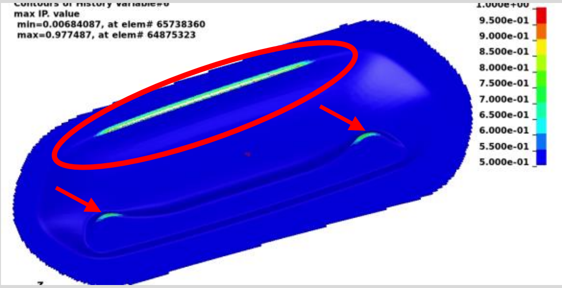


Solid – Blank Shaded view



Demonstrator-Tool Results

Solid – Blank - Damage-Variable – 0.5 bis 1.0



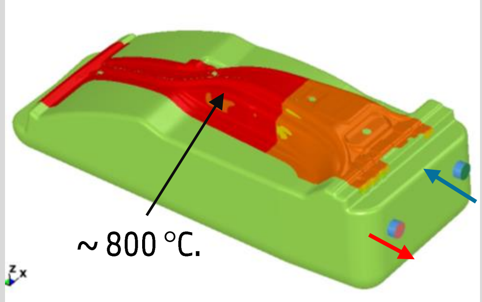
- Simulation with solid blank and fracture model is validated with results from a testing tool.

CURRENT DEVELOPMENTS.
COUPLING A PRESS HARDENING SIMULATION WITH FLUID COOLING.

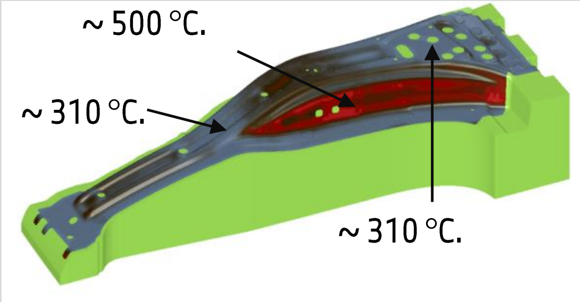
- John Hallquist proposed the “One-Code”-Strategy [19].
- We adopted it to the “One-Input-Deck”-strategy to model all 4 physical disciplines in a object oriented and hierarchical inputdeck in earlier publications.
- A coupled simulation of structure and heat transfer is state of the art – e.g. press hardening with 1 strike.
- A virtual prototype was created for a fully coupled press hardening simulation with water cooling pipes.
- Cooling simulation is a good simulation process to optimize cold deep drawing tools as well. E.g. wheelhouses.

- Virtual b pillar prototype and cold drawing.

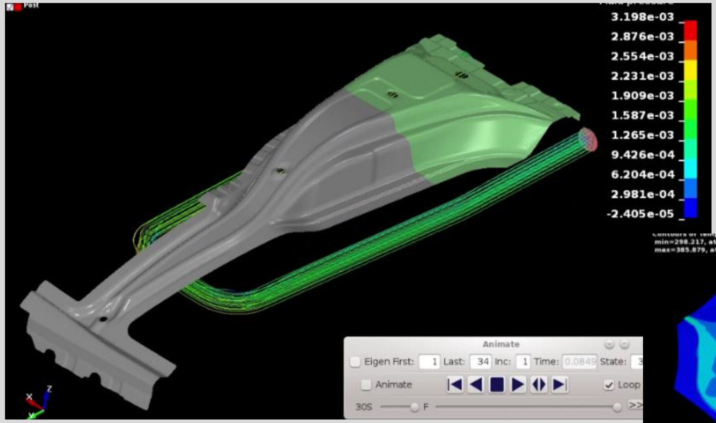
B pillar with u-tube in the punch – Time 0



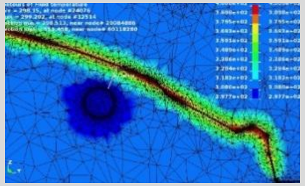
Time 1



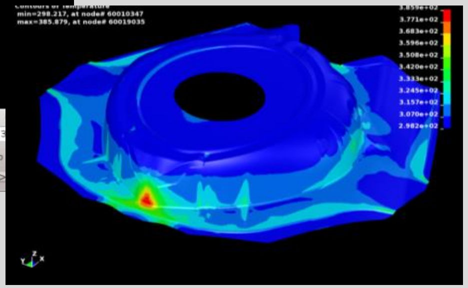
Fluid dynamics for water and temperature



T-plot inside the tool



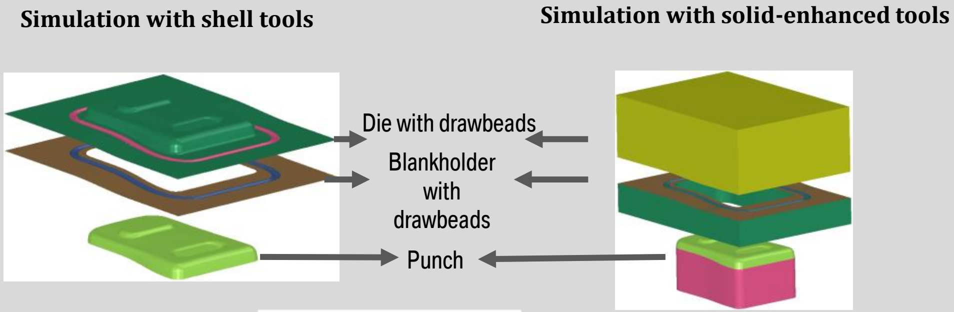
T-plot for a wheel house

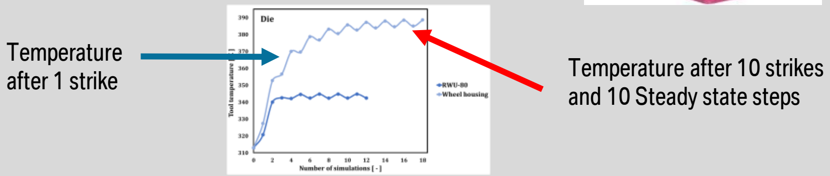


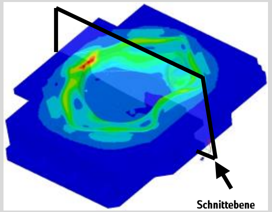
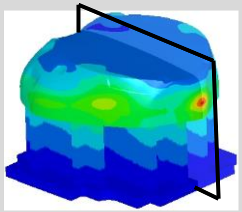
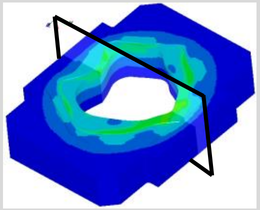
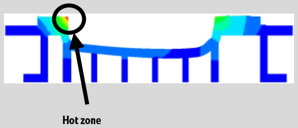
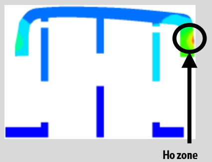
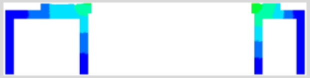
CURRENT DEVELOPMENTS.
THERMO-MECHANICAL CYCLIC SIMULATION.

- A coupled simulation of structure and heat transfer is state of the art – deep drawing with 1 strike.
- A virtual prototype was created for a thermomechanical coupled deep drawing simulation - cyclic loading is applied and combined with “steady state” thermical steps [20].
- Method was transferred to a wheel house – Hot spots can be identified and the final temperature under cyclic loading in series production can be computed.
- Geometry of the tools can be optimized regarding the thermo-design or a cooling system can be applied to the necessary position.

- Virtual wheel house and prototype.



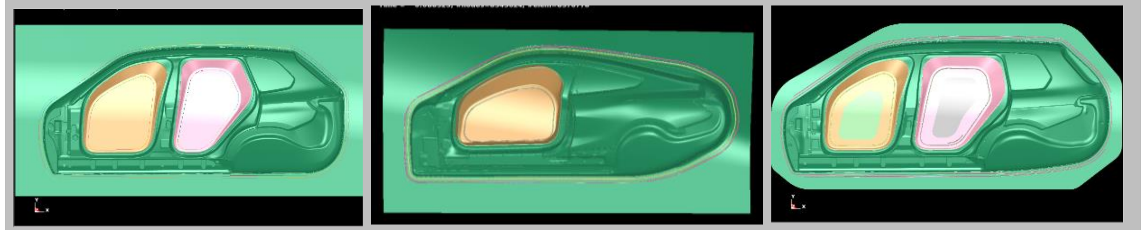


	Die	Punch	Binder
Full			
Plane			

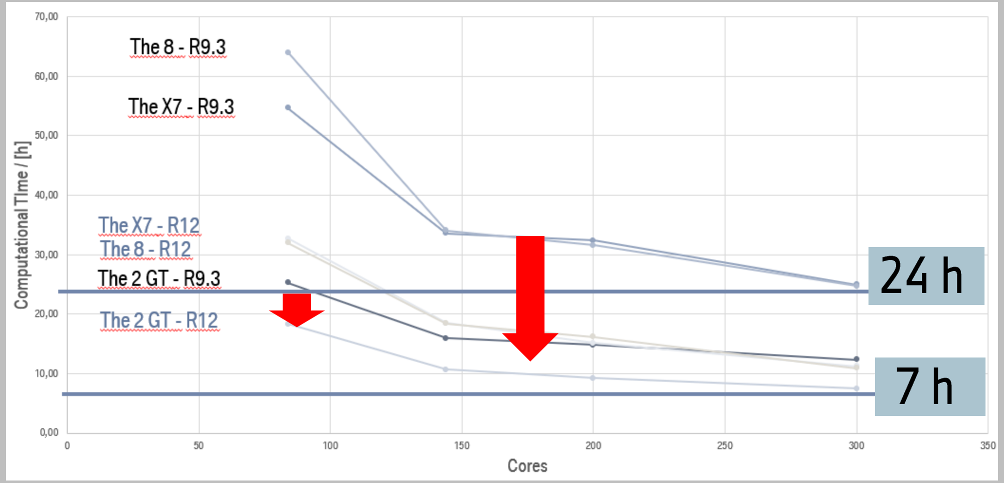
CURRENT DEVELOPMENTS.
LS-DYNA R12 – INCORE-ADAPTIVITY – FIRST RESULTS.

- Usage of R9.3 Solver is state of the art and is running very stable for the standard sheet metal forming simulations.
  - Enhanced by user friction models, material models from Matfem, fracture models, etc.
- A big issue is the time consuming h-adaptivity.
- In LS-DYNA R12, an approach for the incore-adaptivity / dynamic load balancing is implemented.
- The next step will be the usage of this feature in series engineering.
- **Benefit:** Time-Reduction of our models up to 50% depending of the model size.

- The 2 GT.
- The 8.
- The X7.



- Simulation times for big models – with geometrical drawbead and highest accuracy settings.



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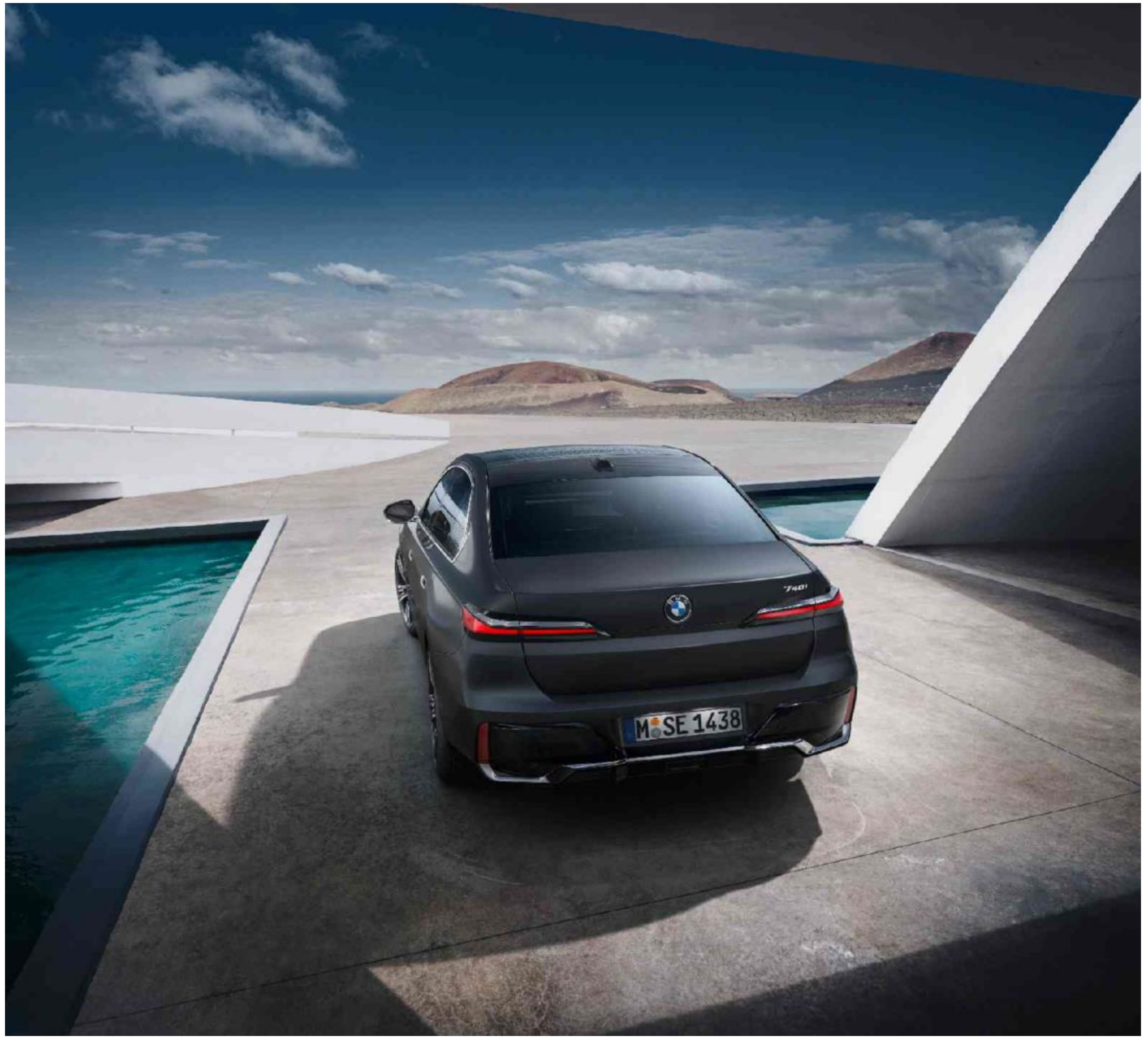
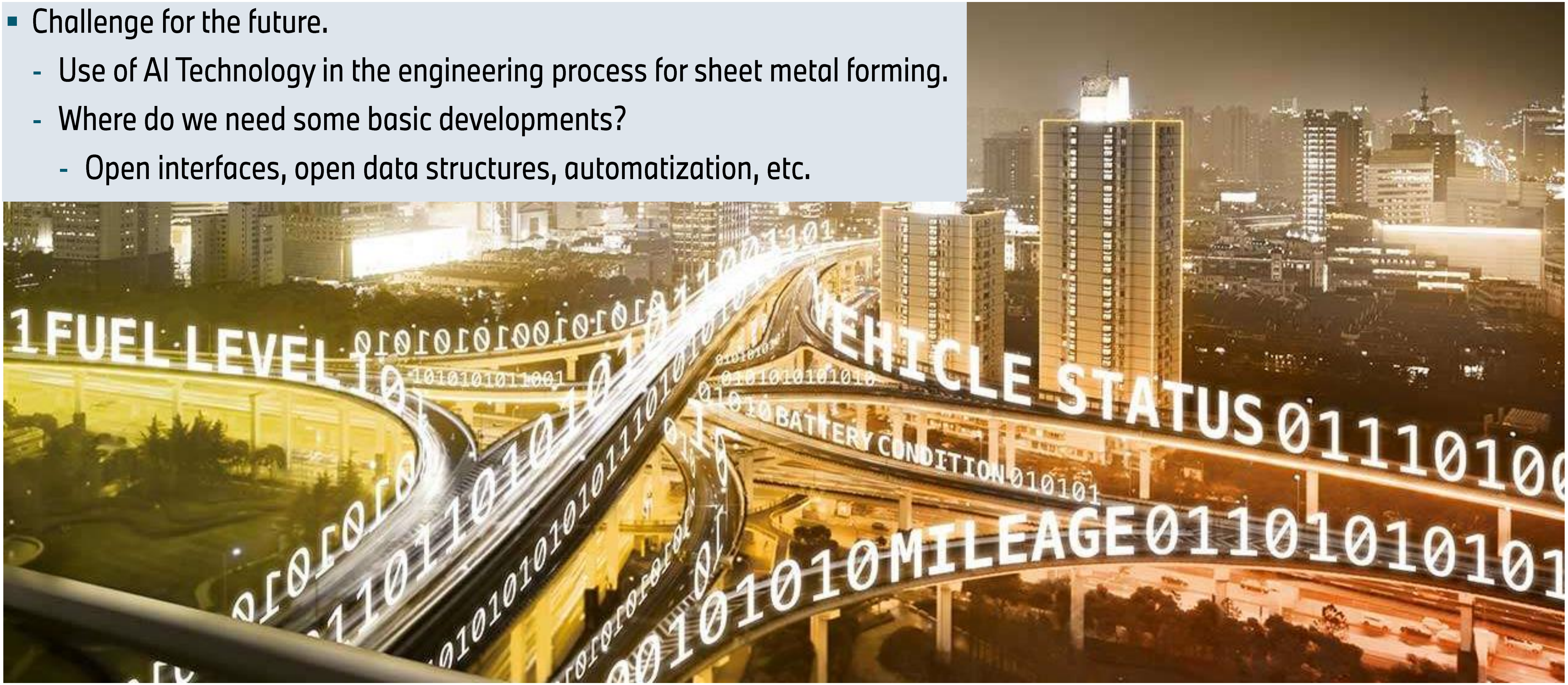
SUMMARY.

- Usage of a meta language in processes for sheet metal forming simulation with FE solver LS-DYNA is state of the art at BMW.
- The enhancement of the “state of the art” simulation processes is a continuous process.
- Simulation technologies like solid elements for the blank or fracture models are applied to the engineering.
- The “One-Inputdeck”-strategy was enhanced by a virtual prototype with fluid cooling for a b-pillar.
- First results with LS-DYNA R12 and Incore-Adaptivity will reduce the computational time.



OUTLOOK.

- Challenge for the future.
  - Use of AI Technology in the engineering process for sheet metal forming.
  - Where do we need some basic developments?
    - Open interfaces, open data structures, automatization, etc.



THANK YOU VERY MUCH FOR YOUR ATTENTION.

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