



Simulation of joining technologies to support JLR new model development

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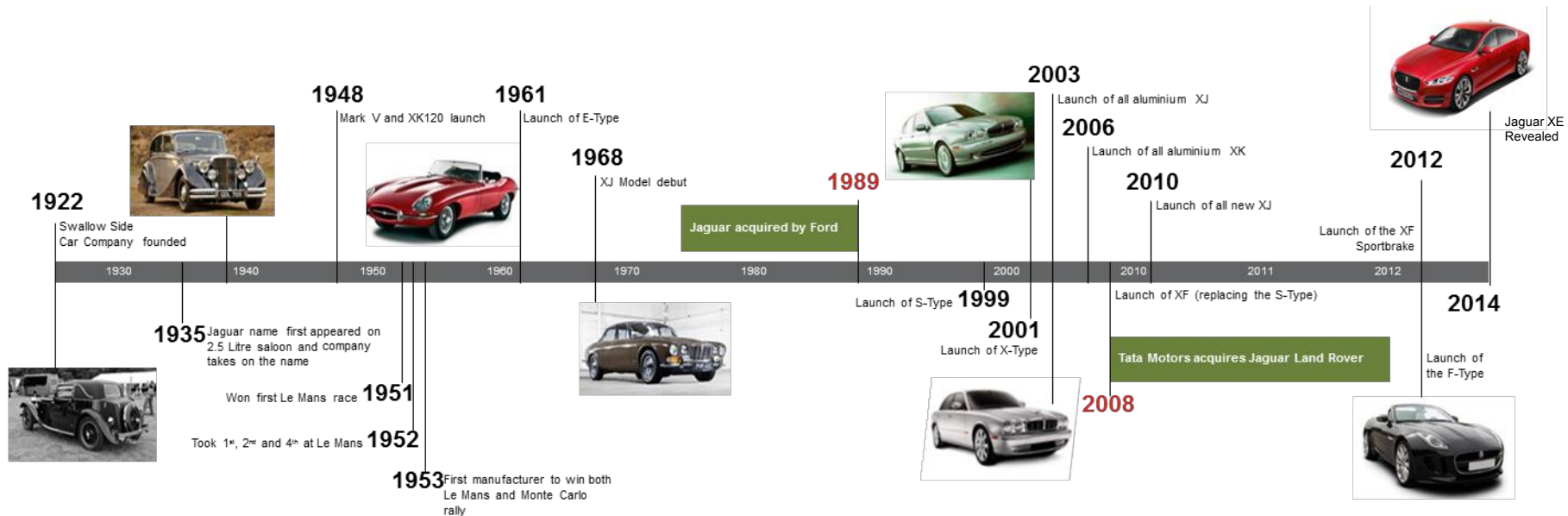
AME, BIW, Joining Technologies

Contents



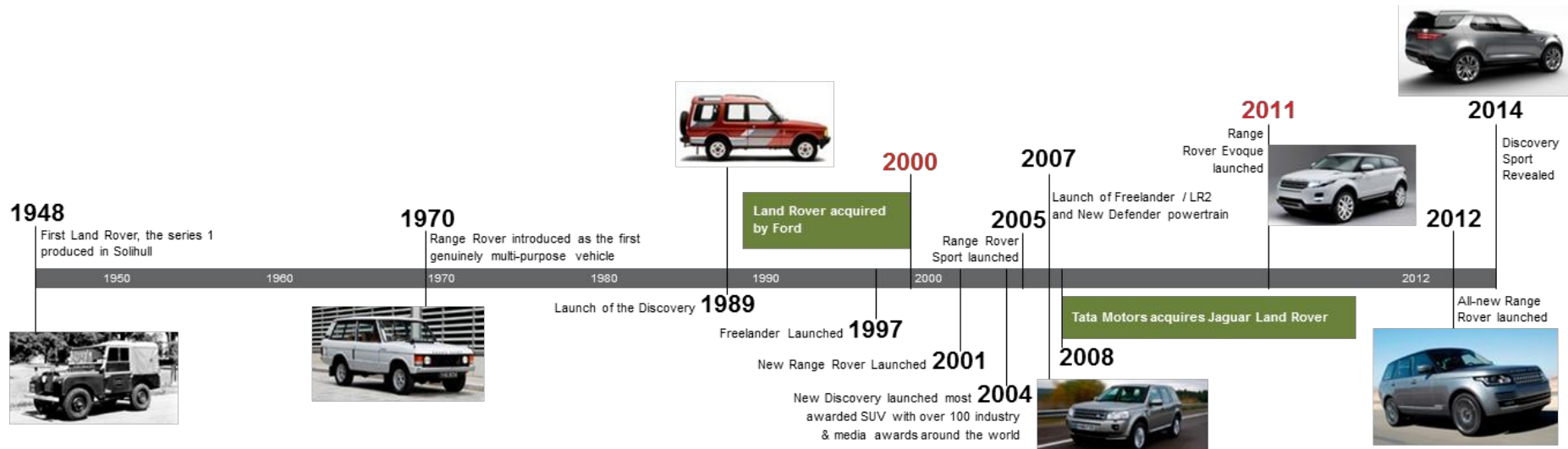
- Introduction
- Joint feasibility simulation
- Joint performance simulation
- Simulation to assist design & production
- Summary and further plan

Jaguar: LWW - a wonderfully rich heritage



- Jaguar, first 60 years was all about making it light for speed & performance - vary much focused on racing & low volume performance cars
- Light Weight Vehicles commercial & high volume products started from 2003 Jaguar all aluminium XJ

Land Rover: LWW - a wonderfully rich heritage



- 1948 Land Rover was clad in aluminium alloy due to steel shortage
- 1989 Discovery had aluminium outer panels attached to steel internal frame for corrosion resistance & light weighting
- 2012 Rang Rover is an all aluminium vehicle

Background

- SPR in JLR Light Weight Vehicles



Jaguar XJ (2003)



Jaguar XE (2015)



Jaguar XF (2015)



Jaguar F-Pace (2016)



Jaguar F-Type (2014)



Discovery (2016)



Range Rover Sport (2013)



Range Rover (2012)

Background

- RSW in JLR Light Weight Vehicles



Range Rover Evoque (2014)



Range Rover Evoque Convertible
(2016)



Discovery Sport (2015)

Resistance Spot Welding (RSW) is the main joining technology for

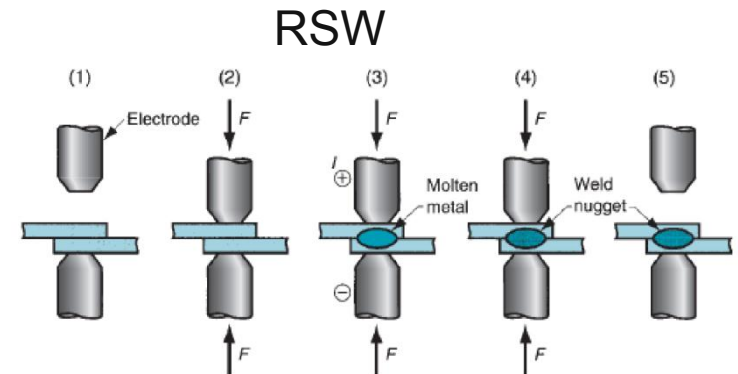
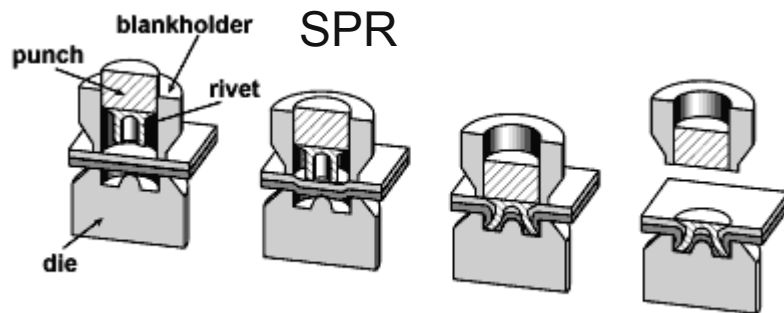
- JLR steel body structure vehicles
- Steel parts in Al vehicles

Background - JLR joining technologies



Self piercing riveting (SPR) and resistance spot welding (RSW) are the two main joining technologies in JLR

- SPR --- Al / Al Al / Steel Steel / Al (2T, 3T, 4T)
- RSW --- Steel / Steel (2T, 3T)



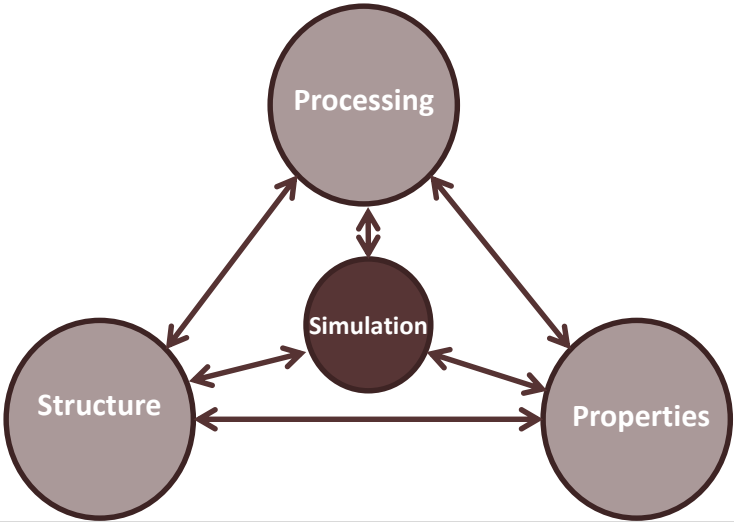
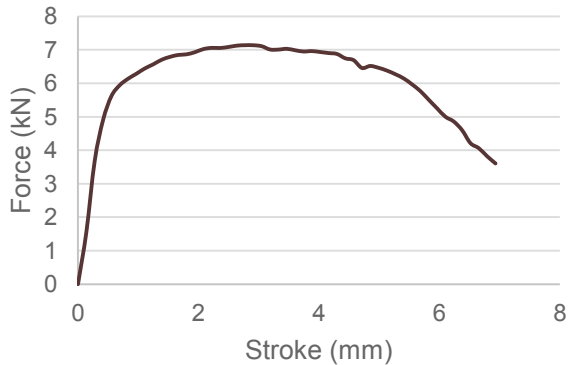
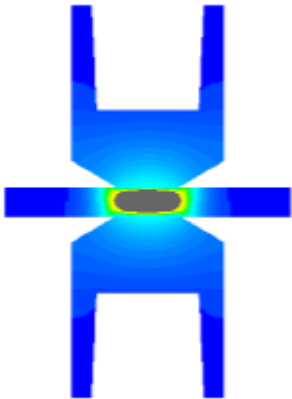
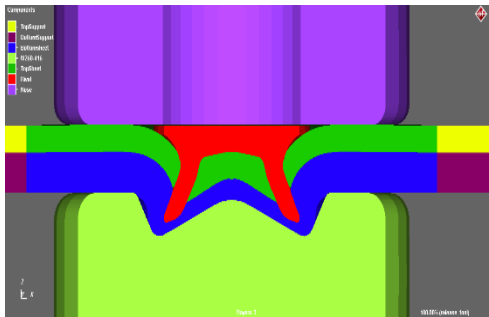
Both SPR and RSW:

- ❖ Requires intensive laboratory tests to confirm joint feasibility and performance
- ❖ Requires a large amount of materials and labour hours for coupon test
- ❖ Human errors difficult to avoid during measurement

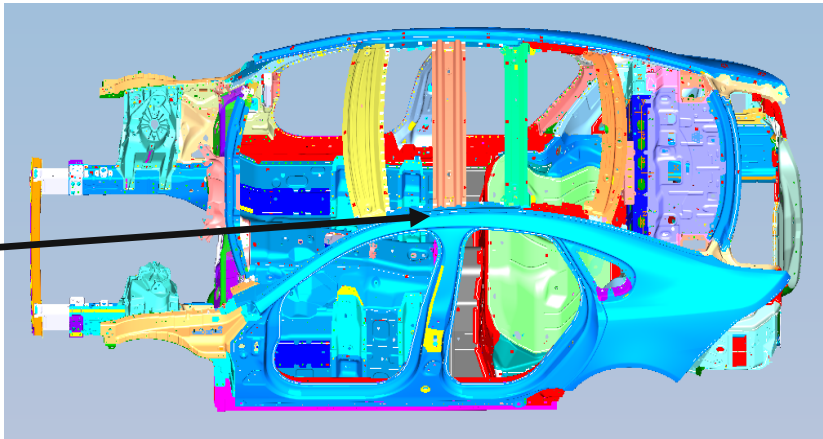
Introduction - Simulation



Stack info		Process parameters		
Materials	Thickness	Rivet	Die	Force
Materials	Thickness	Current	Time	Force



Connecting to all available CAE tools within JLR to support vehicle design and flawless launch in a virtual enterprise.



Simulation for:

- Joint feasibility study
- Deliver process parameters
- Joint performance prediction
- Fast response to materials/process change
- Investigate joint failures in teardown vehicles
- Assist to vehicle design
- Innovation of new joining techniques / new materials

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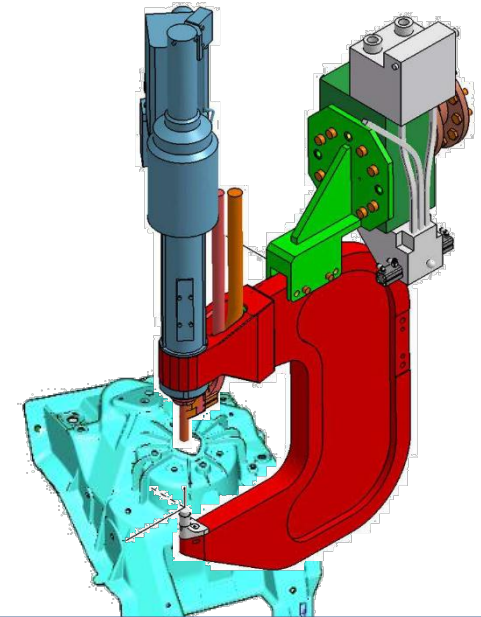
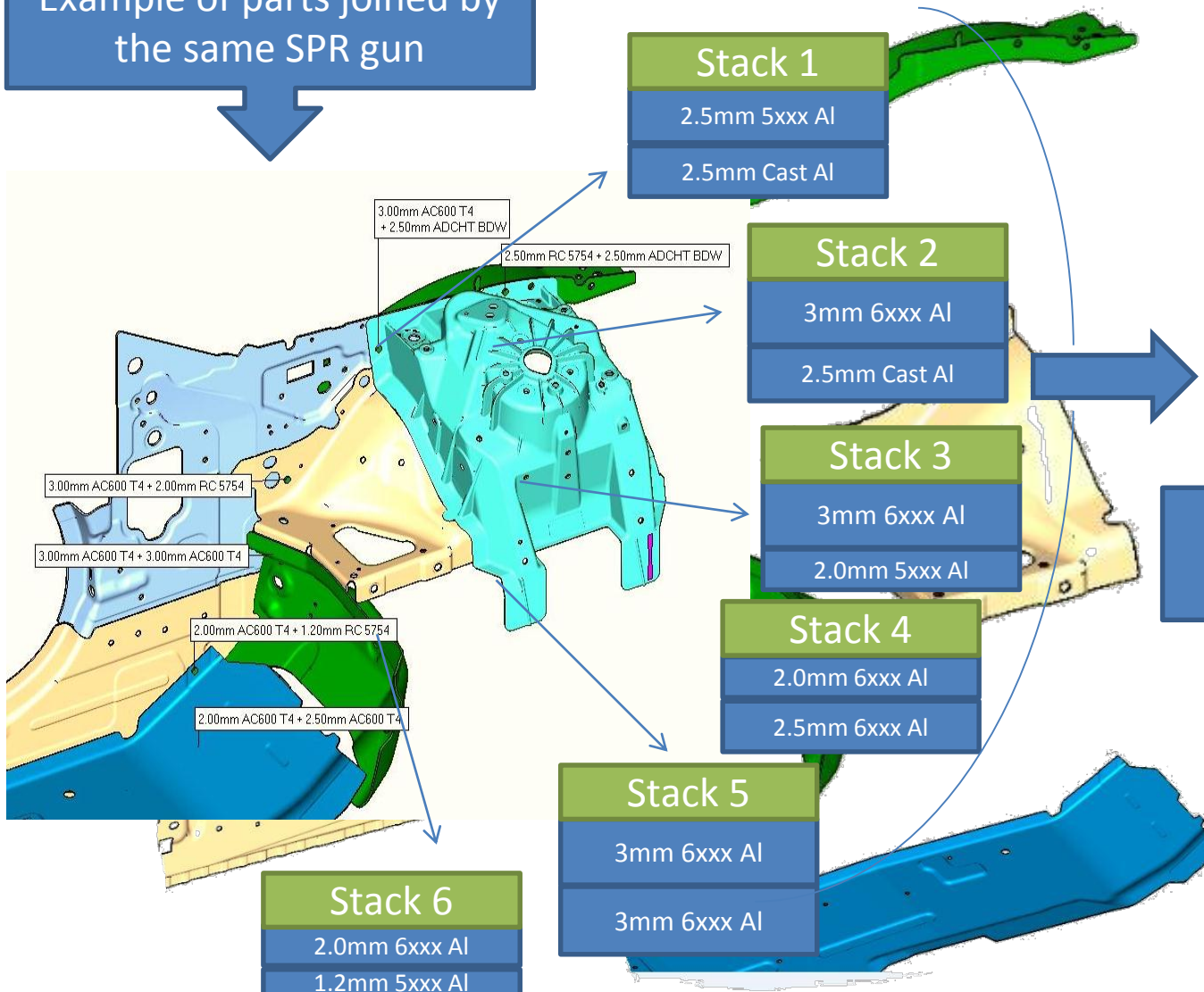


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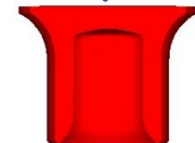
What does joint feasibility mean



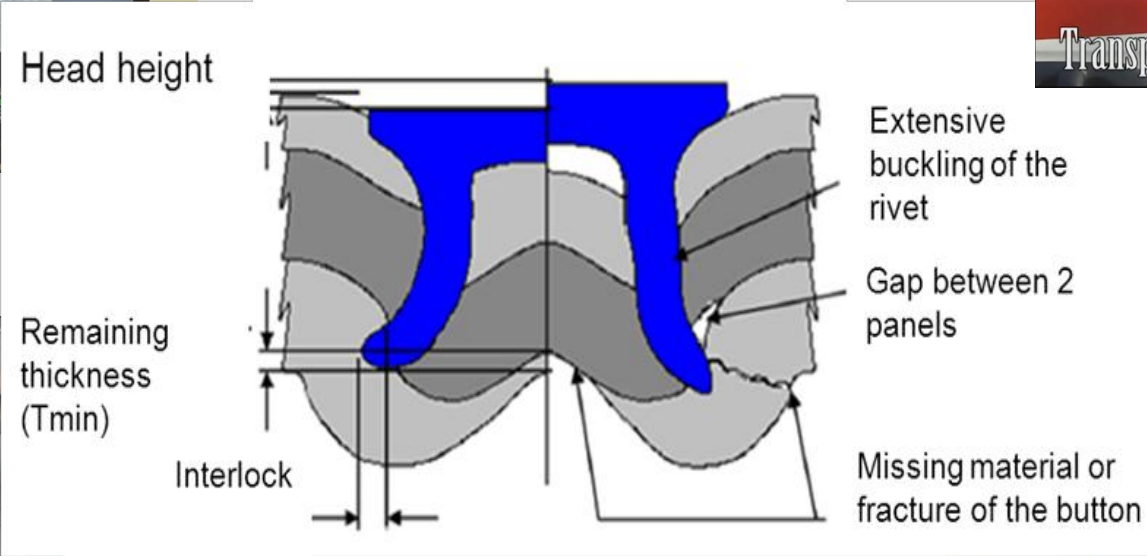
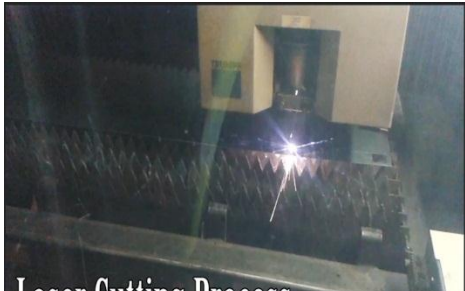
Example of parts joined by the same SPR gun



Selection of a common rivet/die combination



Feasibility evaluation



Feasibility evaluation



Issues of physical coupon test



TIME

30 minutes per section

Over 5,000 sections for a new model

2,500 action hours

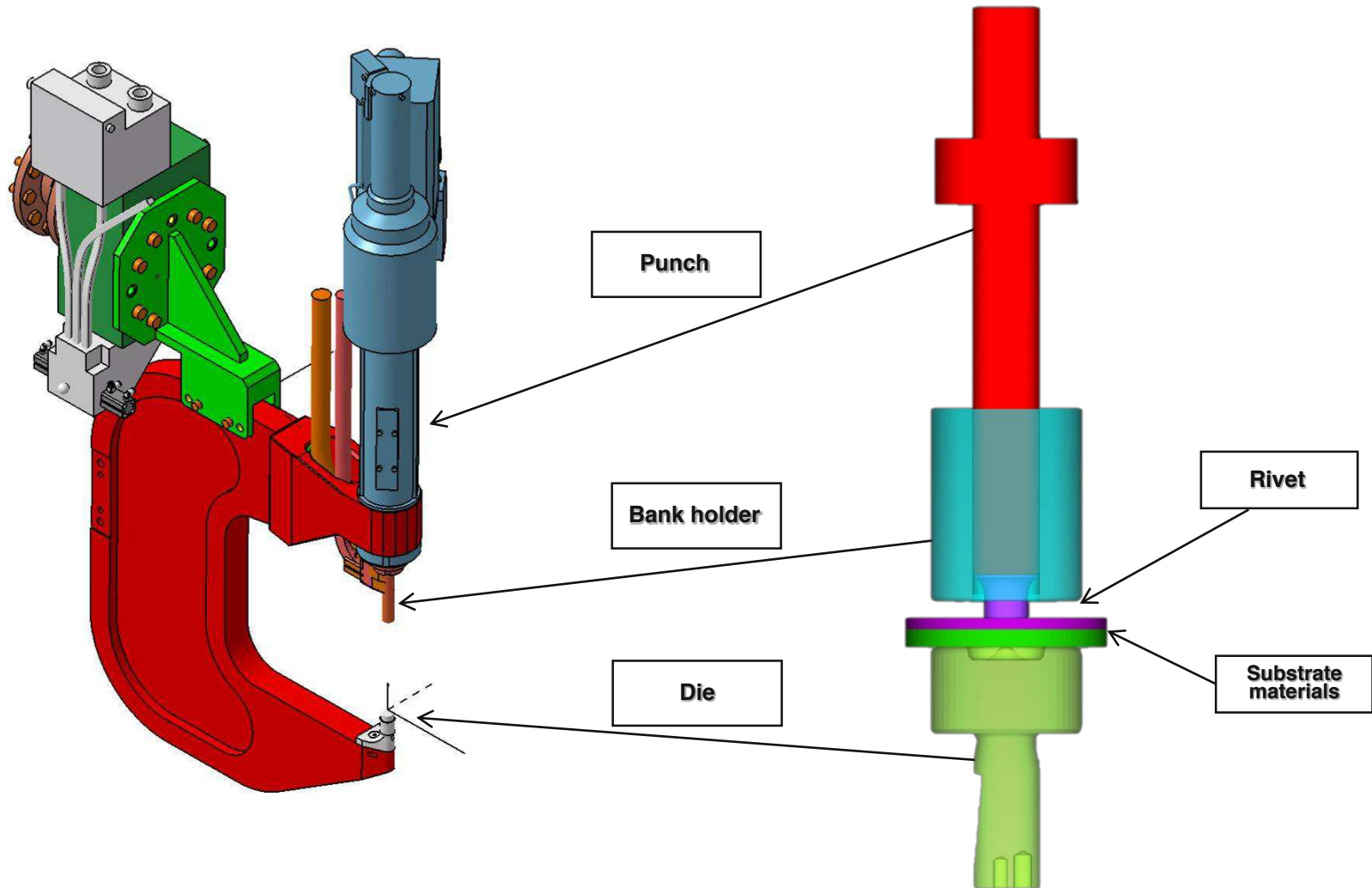
Spending over £1 million



COSTS

Forming, Aging, Surface conditions, Temperature, Fracture mechanism, C-frame, Gun misalignment

CAD Models for SPR process



Challenges – Not just use a software

1

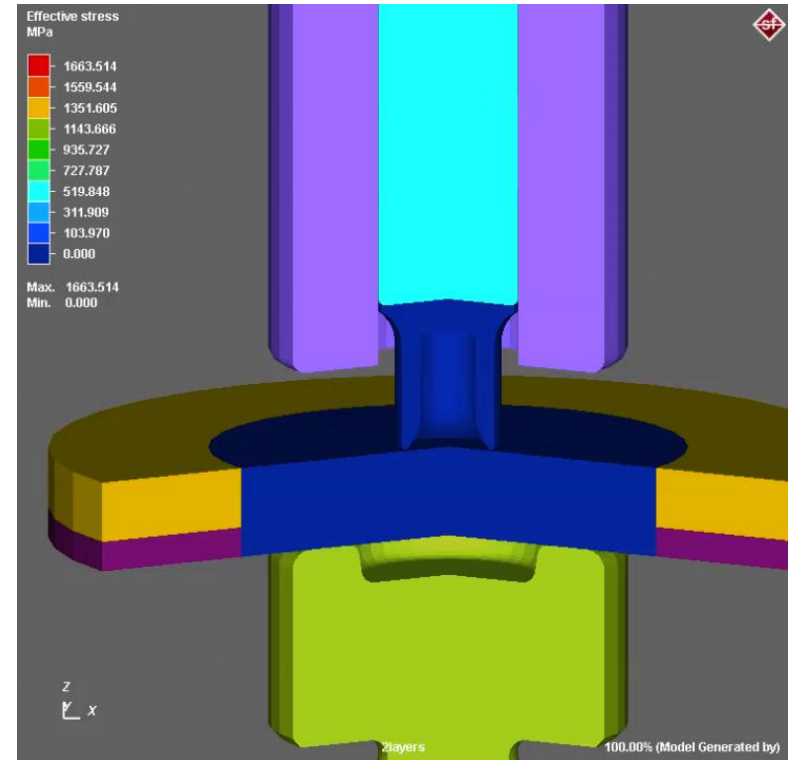
Short CPU time – 10 minutes

2

High accuracy - >85%

3

Suitable for industrial applications



Preparation of input data

- Define materials properties and geometry
- Define the machine (welding) settings
- Define simulation controls



Running simulation

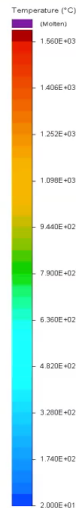
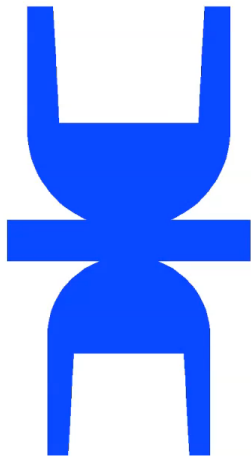
- Call the data file which has all the required information
- Define a location for storing the calculations).
- Start the solver



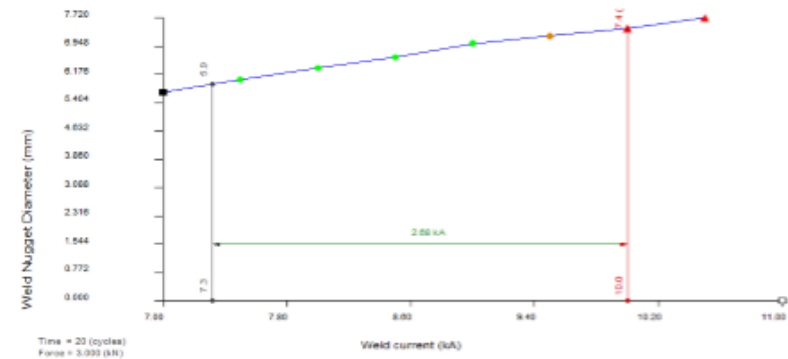
Evaluation of results

- Open the solved data file
- An overview of parameters, thermal history, nugget size, etc.
- Time-temperature plot at a particular location

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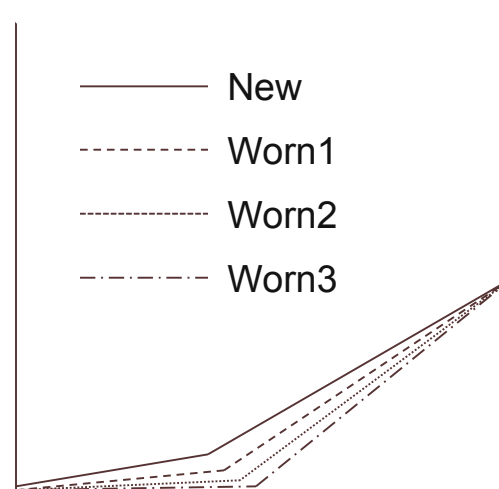
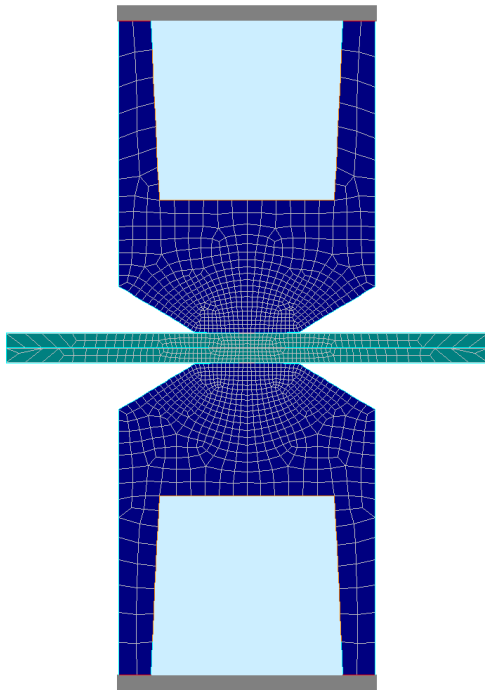


Simulation Result - Process Parameter Curve



0 T(1047) = 20.000 T(1000) = 20.000
8 T(1047) = 1500.0 T(1000) = 1188.0
20 T(1047) = 1500.0 T(1000) = 1188.0

RSW Simulation - Effect of electrode worn



*Electrode geometry can be self designed

Electrode worn



Tip geometry change



Welding current
& force affected

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From SPR to strength test simulation



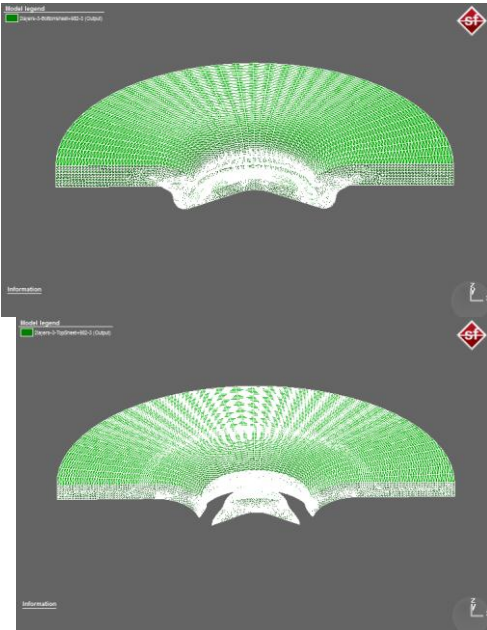
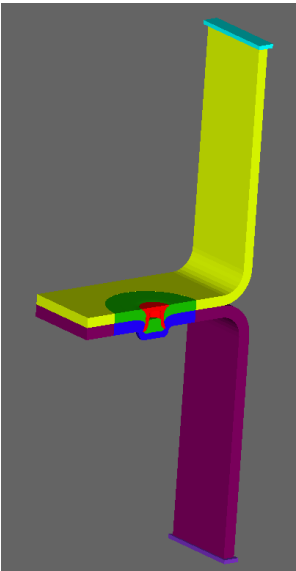
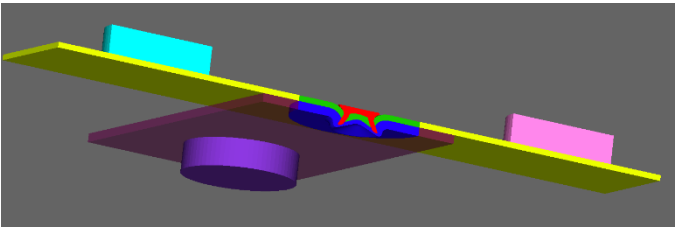
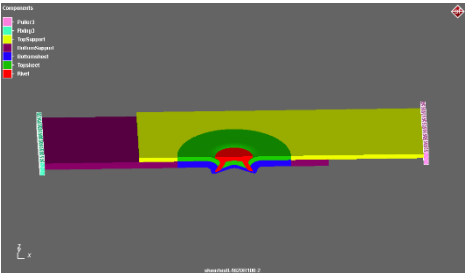
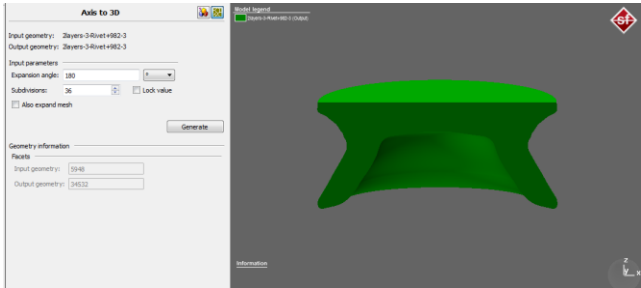
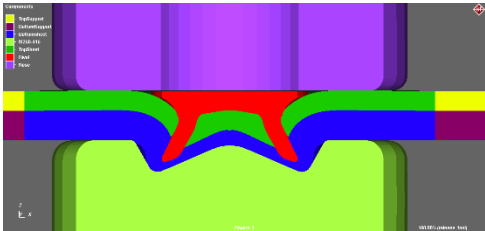
Run 2D SPR simulation

Expand 2D SPR results to 3D

Apply test geometry

Re-mesh for 3D model

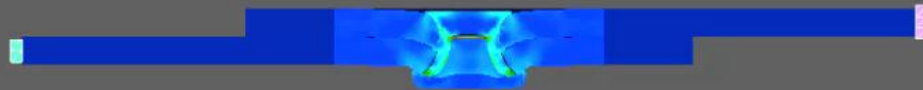
Apply motion



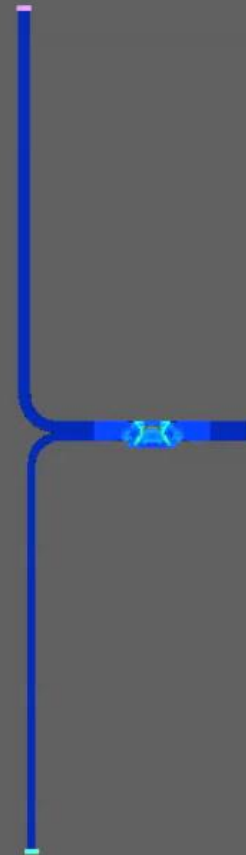
SPR strength tests simulation



Shear test

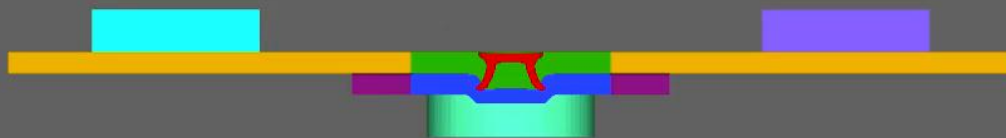


Peel test



PeelL462DR051-2

Cross tension test



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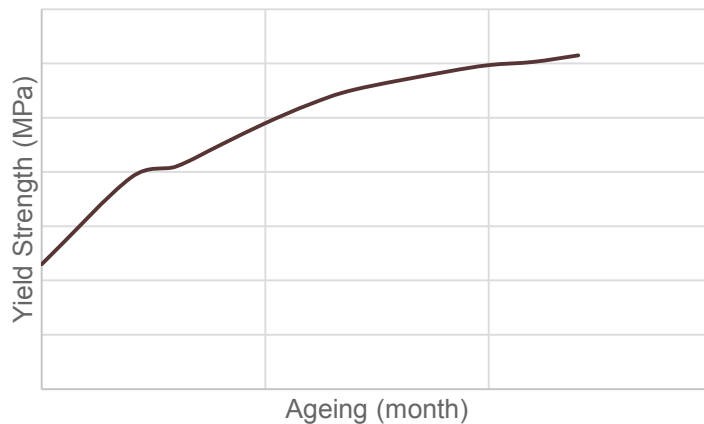
Simulation to assist design & production

- Effect of materials properties variation?

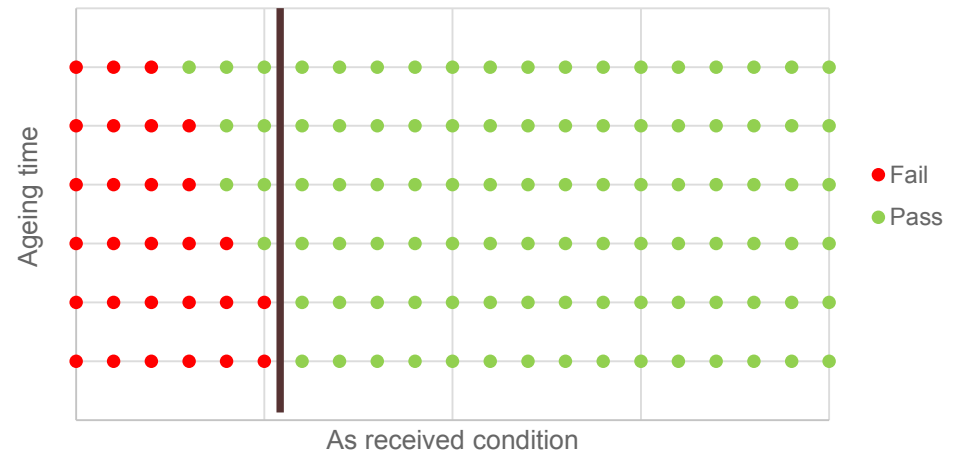


- T4 condition of 6xxx Al alloy suffering materials properties variation during natural ageing
- Simulation to help identify the effect and give solutions

Ageing effect of a JLR 6xxx Al alloy

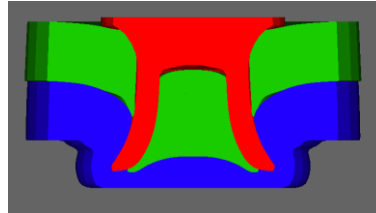


Effect of Al condition on SPR feasibility

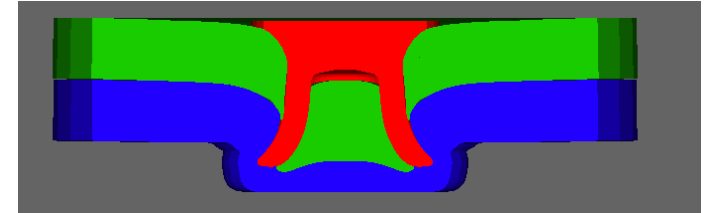


Simulation to assist design & production

- Effect of edge rivets?



Edge rivet

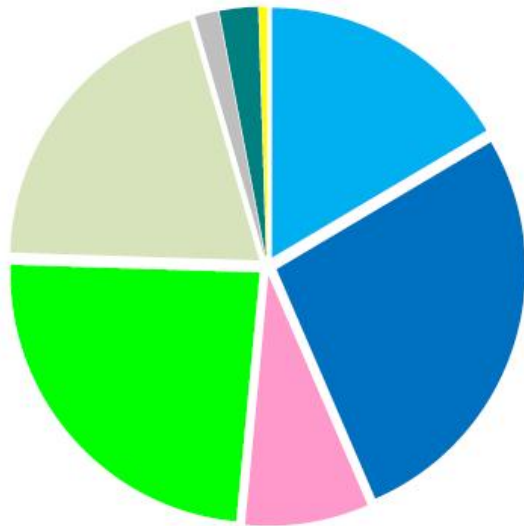


Normal rivet

- Simulation to predict the strength sacrifice for edge rivets
- Assist to vehicle design & production plan

Simulation to assist design & production

- Fast response to change



- Low Strength Steels
- High Strength Steels
- Advanced High Strength Steels
- Alu 6xxx sheet
- Alu 5xxx sheet
- Alu Extrusion
- Alu Cast
- Magnesium



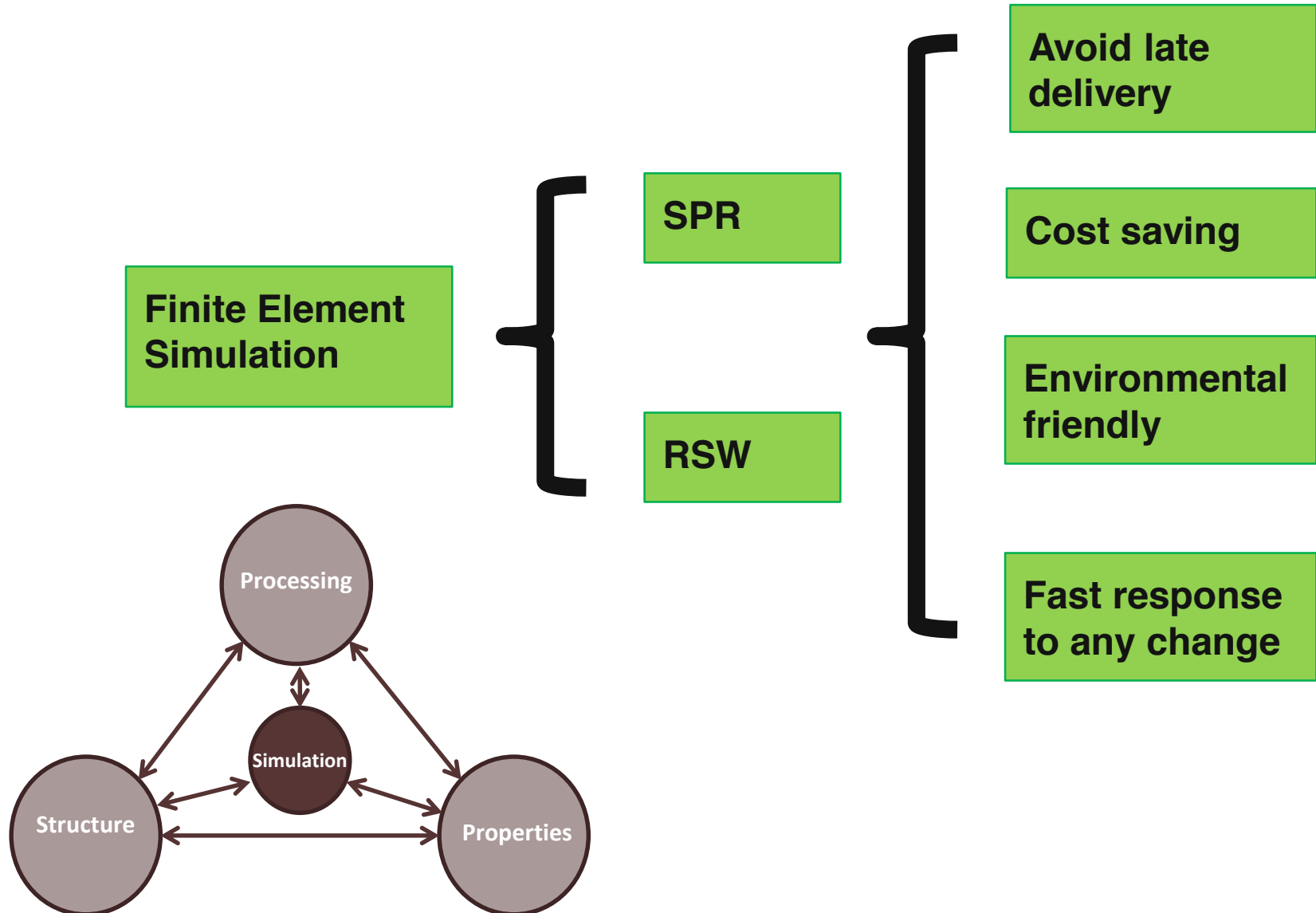
- Materials delivery and preparation time can be saved
- Fast response to the materials / design change
- Accelerate the feasibility study for new materials

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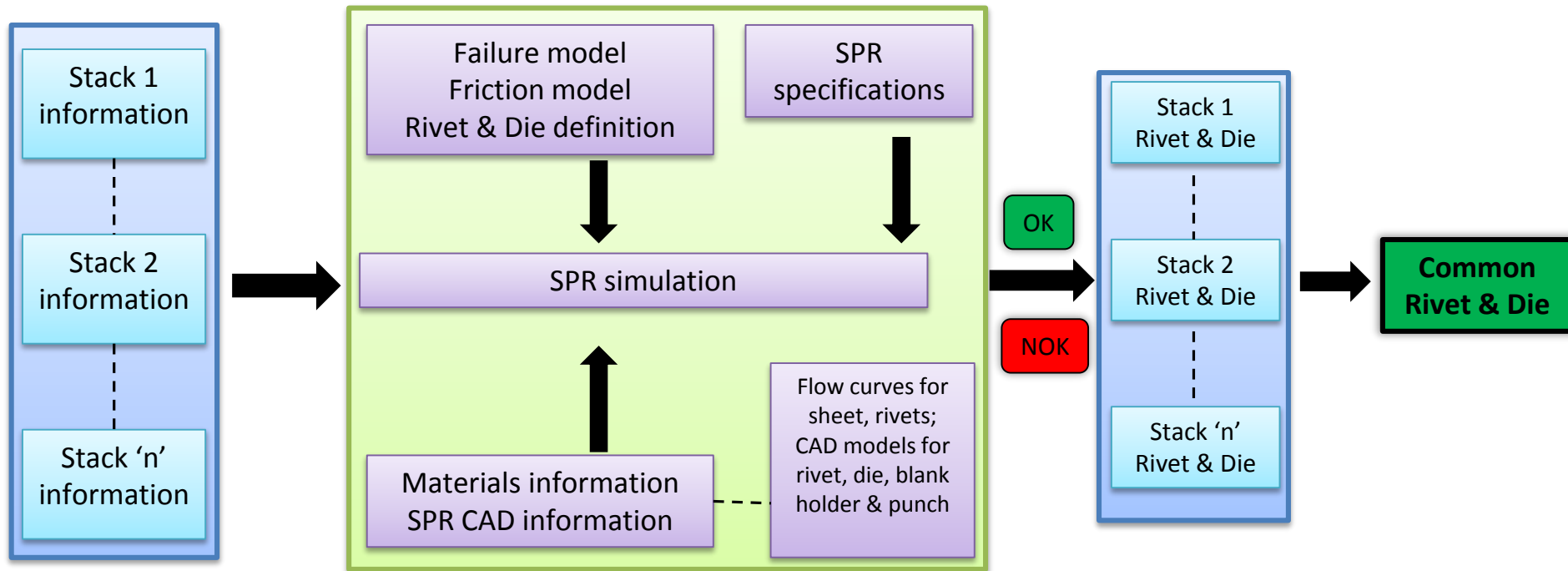
Summary



Further development



Ultimate goal: Input stack information → output feasibility prediction



We can make it even faster...



Thank you
Danke
謝謝
Grazie
Merci
Gracias



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