Towards zero emission vehicles using composites with recycled thermoplastics

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THE SWEDISH Manufacturing R&D Clusters

Zero Emission electric Vehicles enabled by haRmonised circulArity

The ZEvRA project

Towards zero emission vehicles using composites with recycled thermoplastics

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RISE

2026-05-20

This project has received funding from the European Union's Horizon Europe research and innovation programme under Grant Agreement No. 101138034

Funded by the European Union

ZEvRA – Zero Emission electic vehicles enabled by harmonised circularity

Key Figures

- Grant Authority: EUROPEAN CLIMATE, INFRASTRUCTURE AND ENVIRONMENT EXECUTIVE AGENCY (CINEA) (**G.A. no. 101138034**)
- Call Topic: Circular economy approaches for zero emission vehicles (RIA) – D5-01-04
- Grant: **€ 11.4 million** from the EU **+ UNN share** from the UK
- Duration **3 years** from **1st January 2024** to **31th December 2026**
- **28 partners** from **13 countries and over 1150 person months work**

- **Main objective:** improve the circularity of light-duty electric vehicles throughout their value chain, from material sourcing to manufacturing and end-of-life processes
- Coordinated by Fraunhofer IWU

ZEvRA – Zero Emission electic vehicles enabled by harmonised circularity

Consortium

VOLKSWAGEN GROUP

STELLANTIS
CRF
STELLANTIS
SKODA
EDAG
Havel metal foam
farplas
bay Bay Zoltán Nonprofit Ltd. for Applied Research
COMPOSITEC Think Composites
TOYOTA
Continental The Future in Motion
BENTELER makes it happen
NTNU
RAFFMETAL
ENDURANCE
POLYMERIS Competitiveness cluster for rubbers, plastics and composites
apra europe
RKW Sachsen Wege für den Mittelstand
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ZEvRA – Zero Emission electic vehicles enabled by harmonised circularity

Ambition and overall objectives

Main objective: improve the circularity of light-duty electric vehicles throughout their value chain, from material sourcing to manufacturing and end-of-life processes

1. Developing Design for Circularity methodology and a holistic circularity assessment

2. Validate Obj. 1. by developing zero-emission solutions for 8 use cases

3. Circular Car Concept based on the Skoda Enyac which integrates objective 2.

4. Awareness and acceptability of the circularity strategy by demonstrating key aspects and advantages

5. Virtual learning and educational platform for training and upskilling of the industrial workforce

6. Adopt circular business models (CBMs) to the project's zero emission solutions

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Work Packages

WP 1 Circular Economy Methodology

WP 2 Digital Tools

WP 3 Circular Car Prototype

WP4 Use Case Prototypes

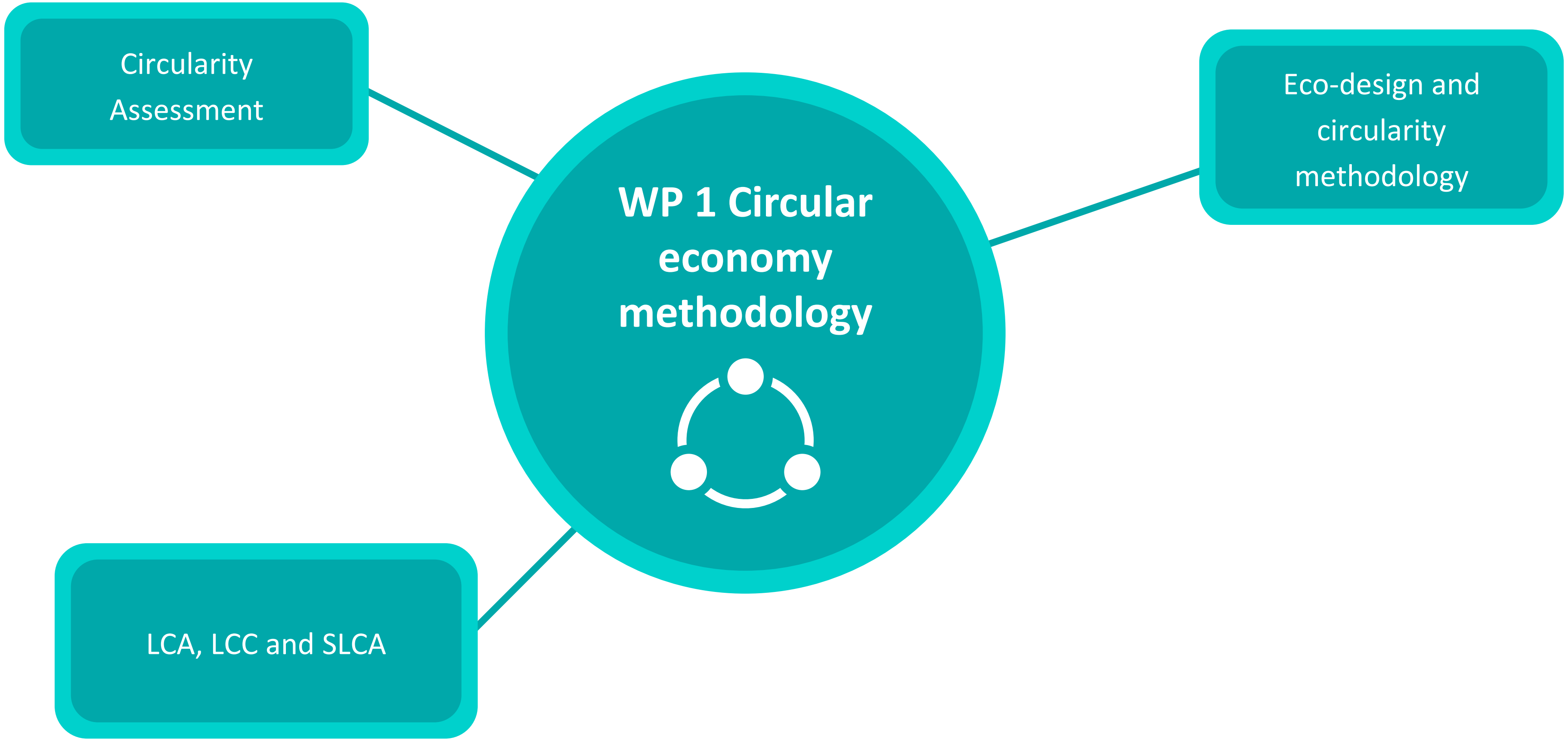
WP 5 Awareness, Acceptability and Training

WP 6 Dissemination, Communication and Exploitation

WP7 Project Management and Coordination

ZEvRA – Zero Emission electic vehicles enabled by harmonised circularity

WP structure of ZEvRA



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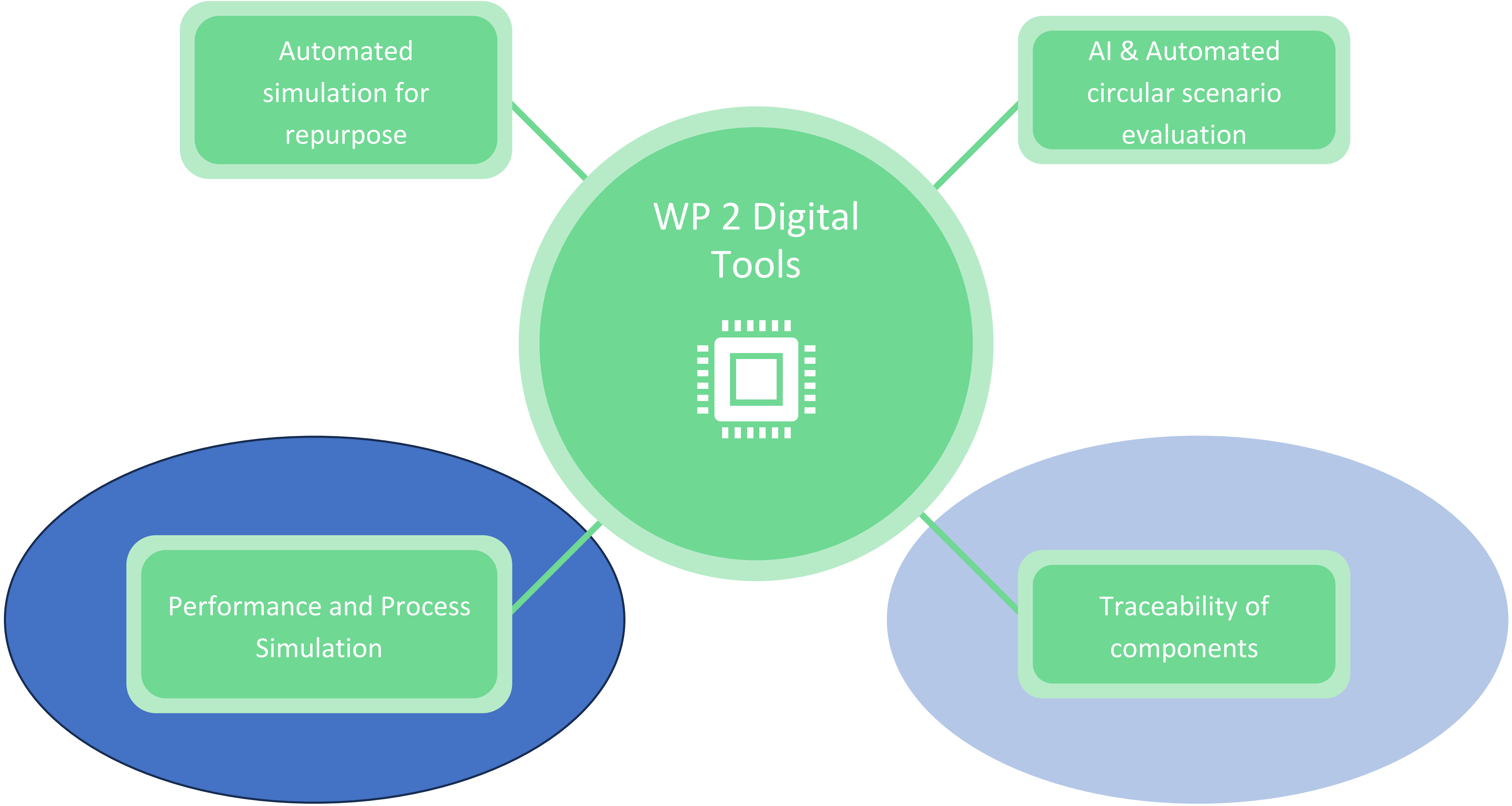
WP structure of ZEvRA



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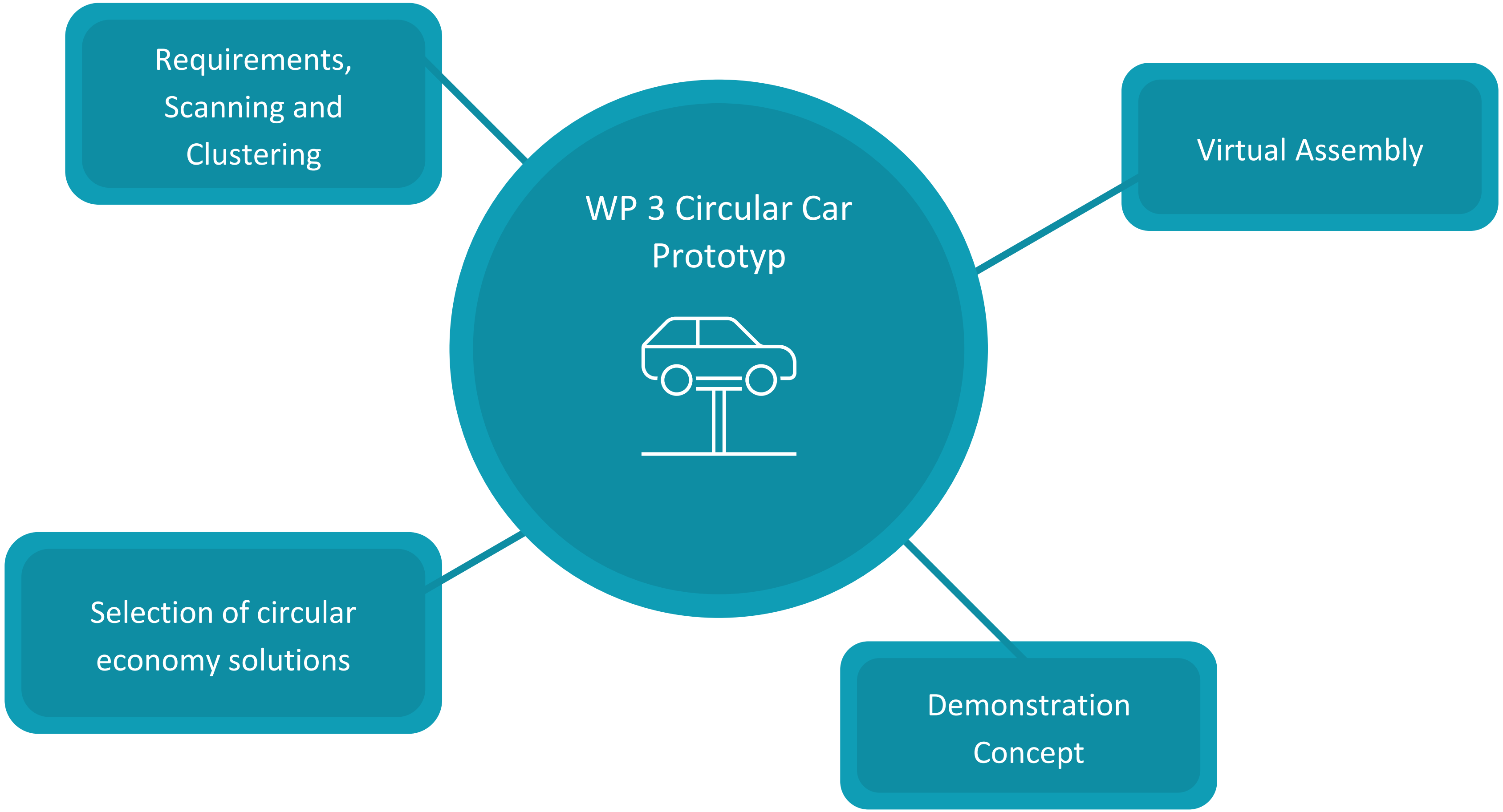
WP structure of ZEvRA



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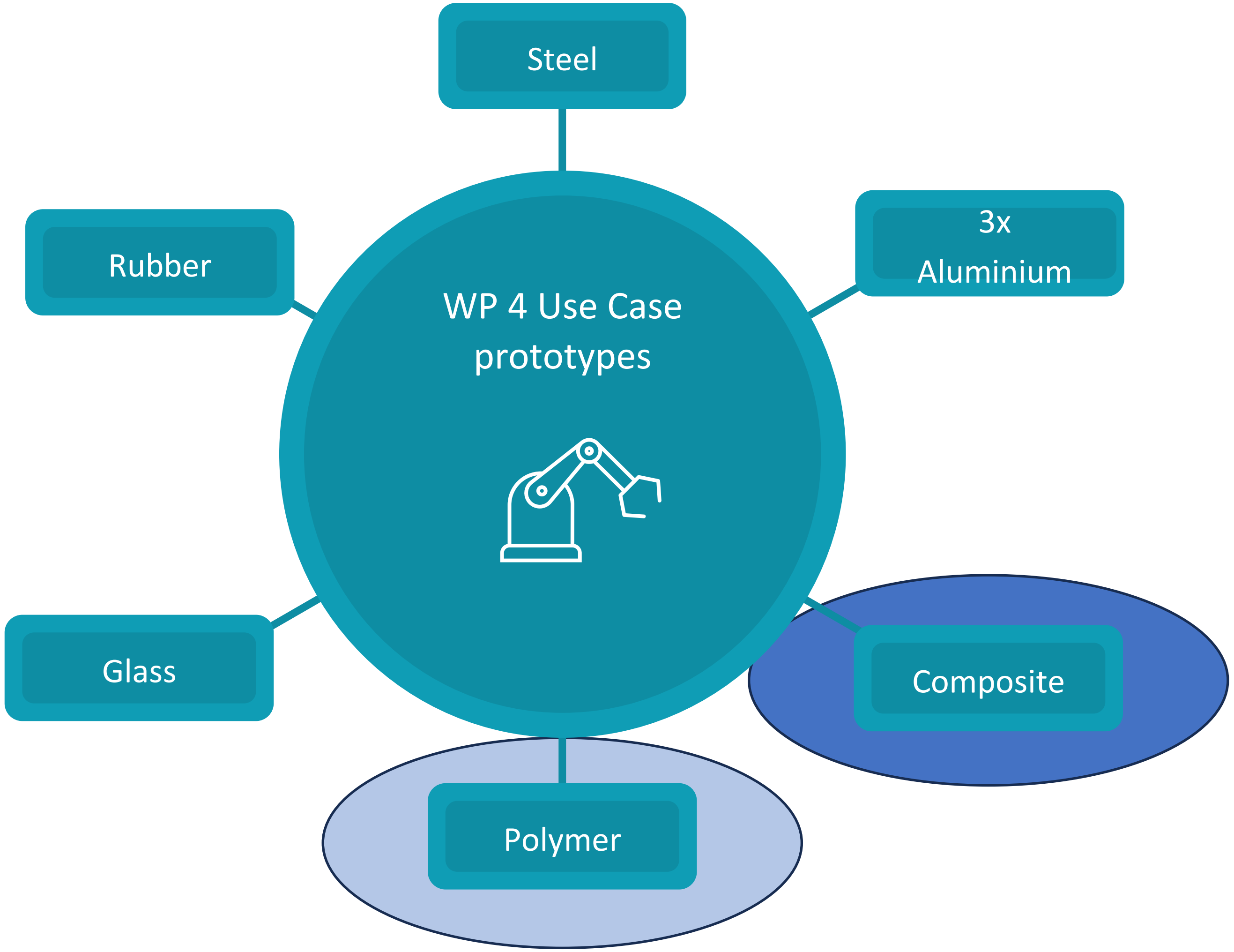
WP structure of ZEvRA



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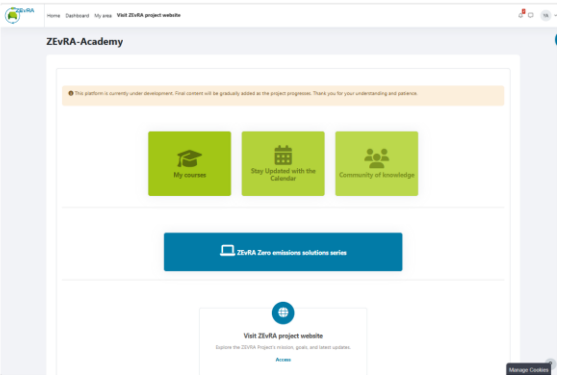
WP structure of ZEvRA

WP 5
Awareness, Acceptability and Training

Awareness & Acceptability

Clusters and Networking

Training Activities and Educational Material



Digital tools support composite processing of recycled material

Comparison to biobased material

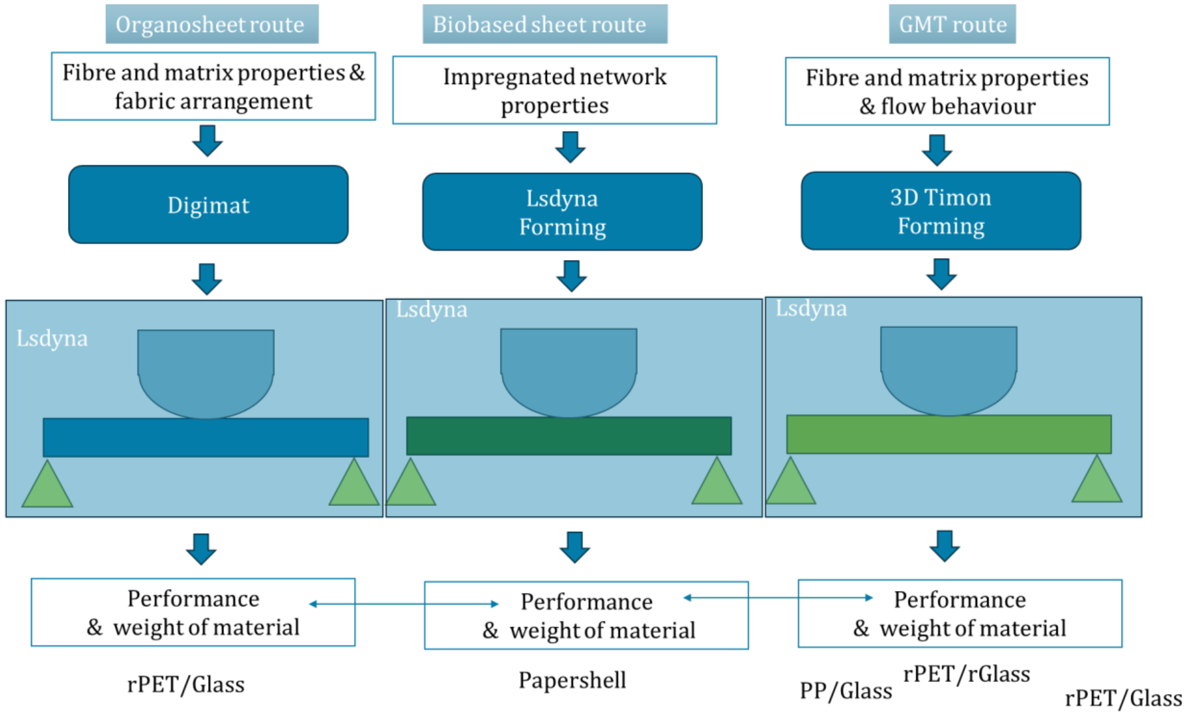
The composites are made up of three types:

(1) recyclate matrices with continuous fibres (organosheets),

(2) recycled thermoplastic composites in the form of thermoplastic impregnated glass mats (GMT)

(3) biobased materials (in this case resin impregnated kraft paper)

The diagram show how each of them will be processed and finally compared to each other.



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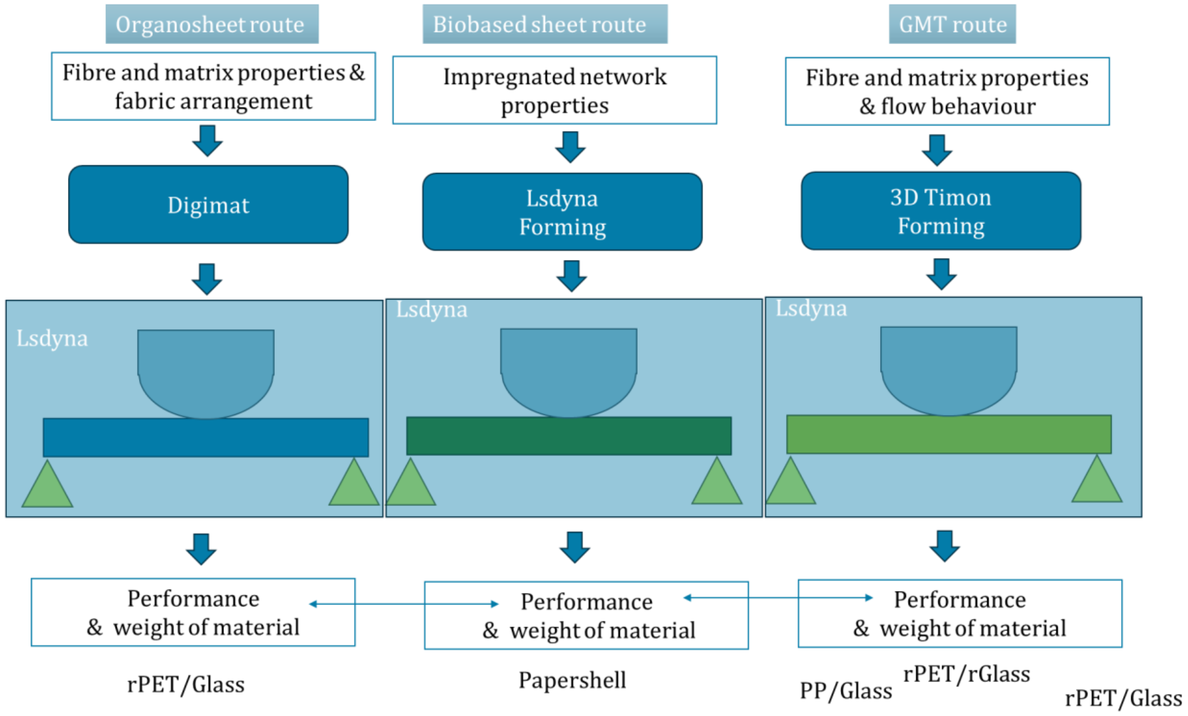


Squeeze test for characterisation of GMT-PET

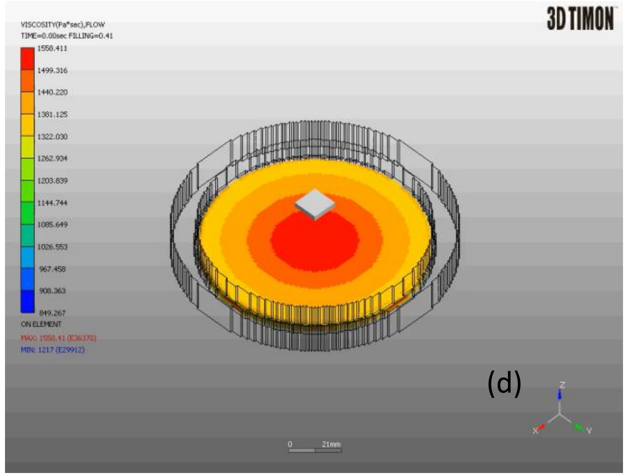
Composites – GMT

- Material:
  - This material, currently employed in the production of battery lids, will serve as the benchmark for evaluating the performance of recycled alternatives
  - GMT blanks of rPETGF30 (Glass content is 30 wt%)
  - Melting point of PET is 250°C

Procedure:

- Viscosity characterisation done at 260 °C, 275 °C and 290 °C
- Material is heated to require temperature and is squeezed between two heat plates also set at the required temperature
- 5 tests of each temperature were done
- Test simulated and viscosity values set so simulated clamp force matches compaction force

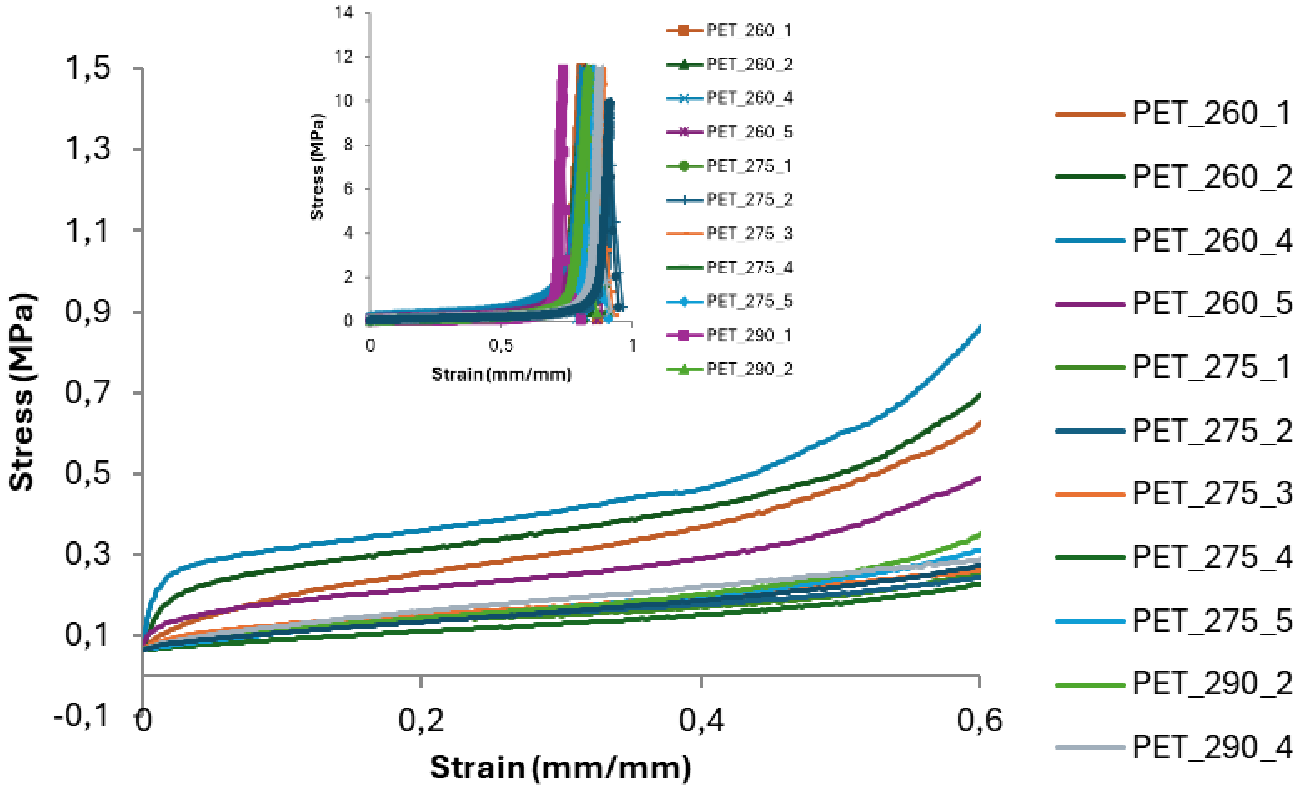
(b)



(d)

Characterisation of viscosity

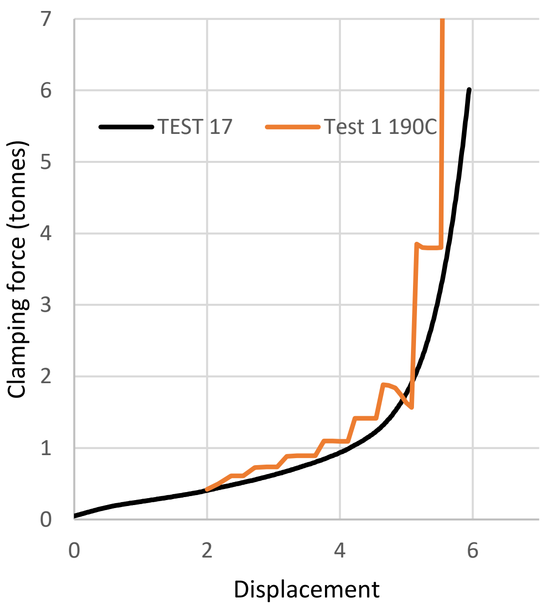
Results of squeeze test

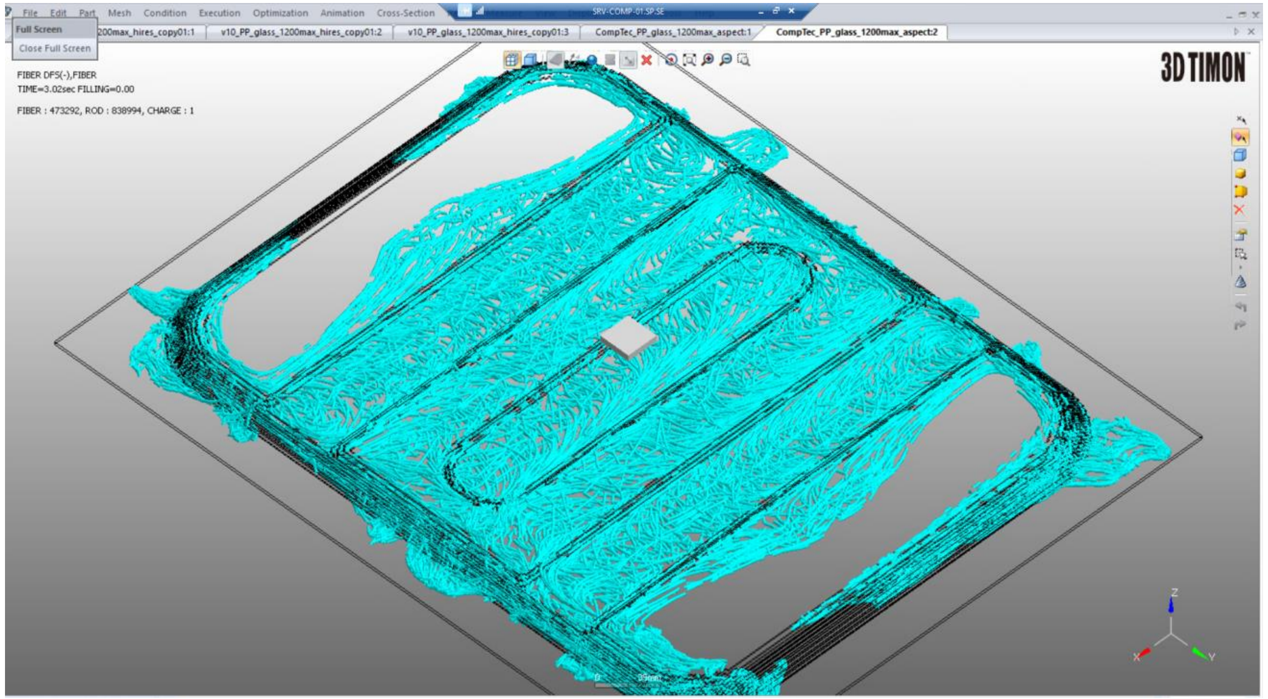


Fitting the whole curve…

Shear thinning too high

- No fibre-fibre interaction



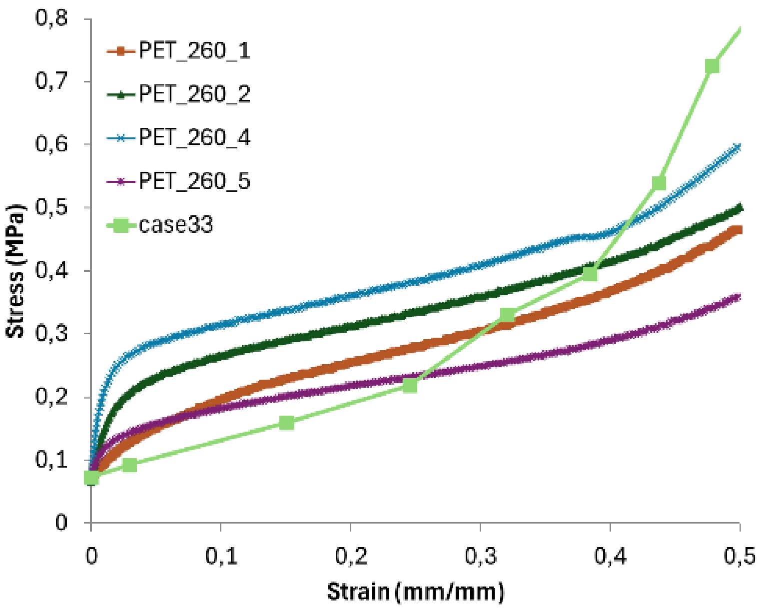


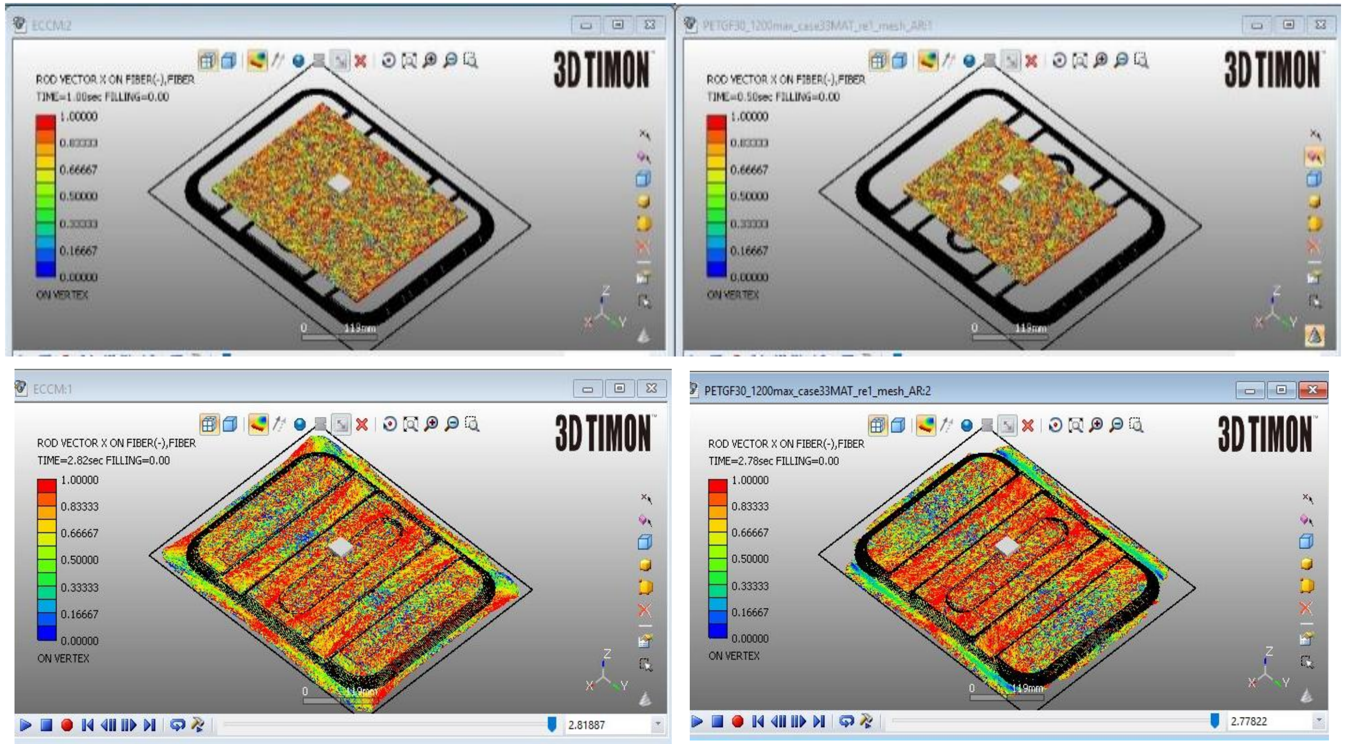
Challenges: Very high initial viscosity
Followed by much lower viscosity as fibre move – usual mechanism is shear thinning, but here shear rate is low, so initiated by shear rate but then expect it drops off

$$\eta = \frac{\eta_0}{1 + (\eta_o \dot{\gamma})^{(1-n)}}$$

$$\eta_0 = D_1 \, e^{\frac{-A_1(T-(D_2+D_3 \cdot p))}{A_2+T \cdot D_2}}$$

Battery enclosure lid simulations



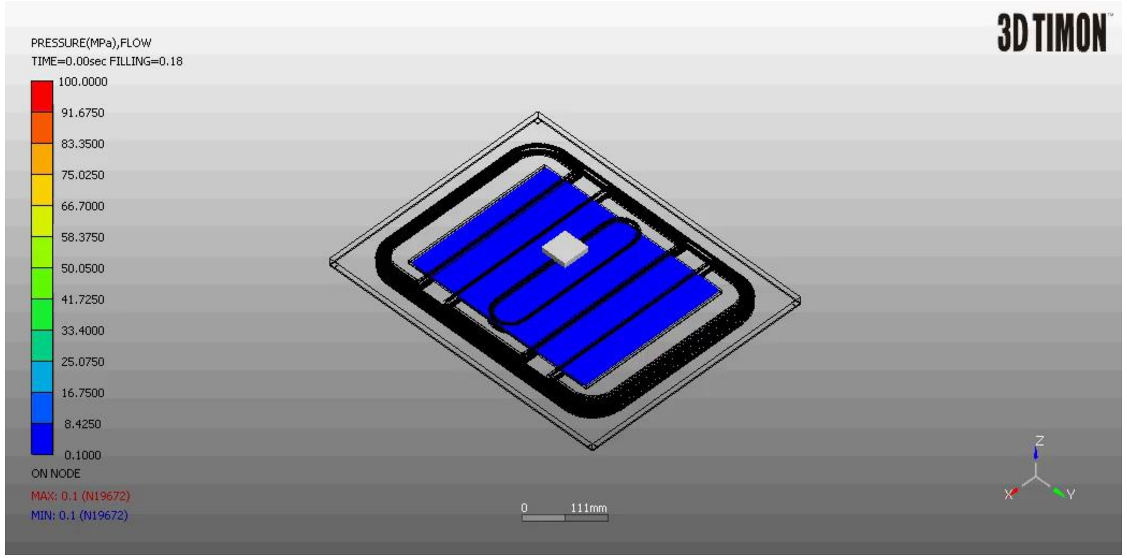


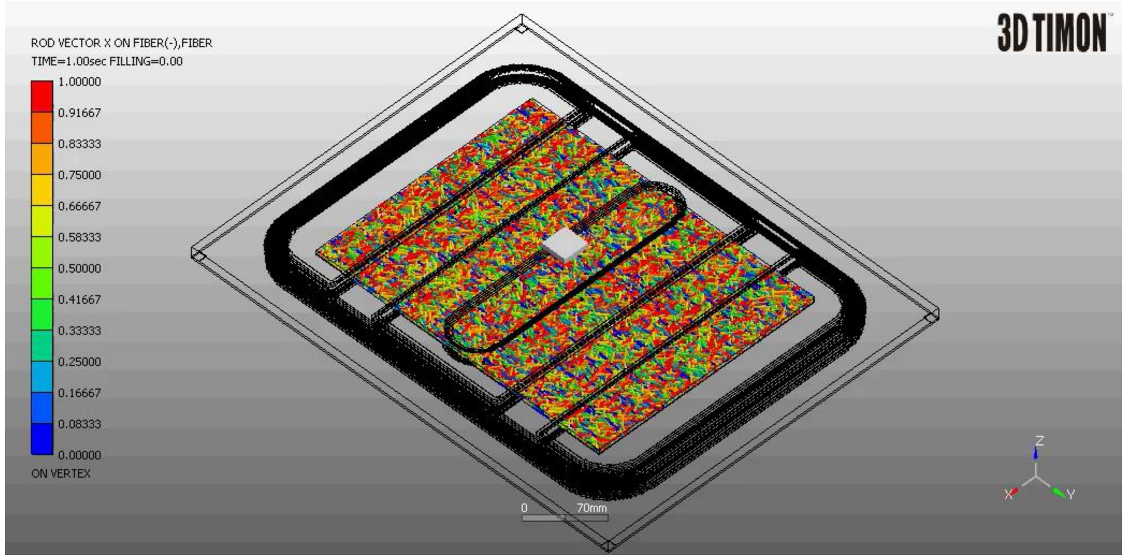
Wrong viscosity model: Compromise on fit

Allow reasonable prediction of clamp force
Prevents runaway from excess shear thinning

Process simulation

Pressure and fibre orientation

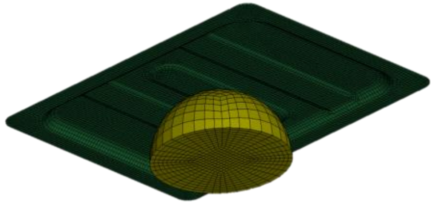


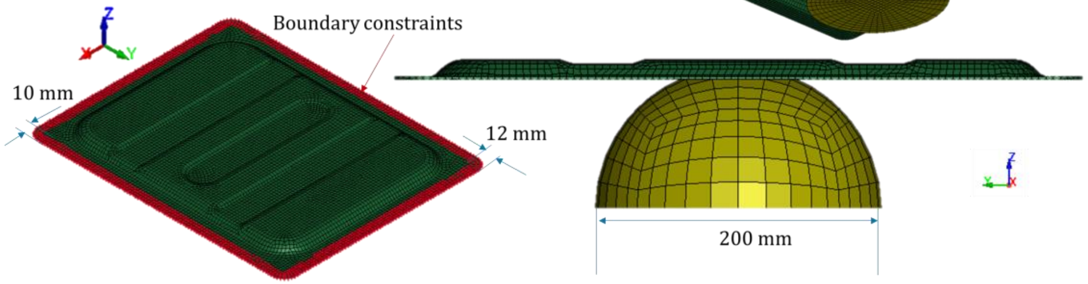


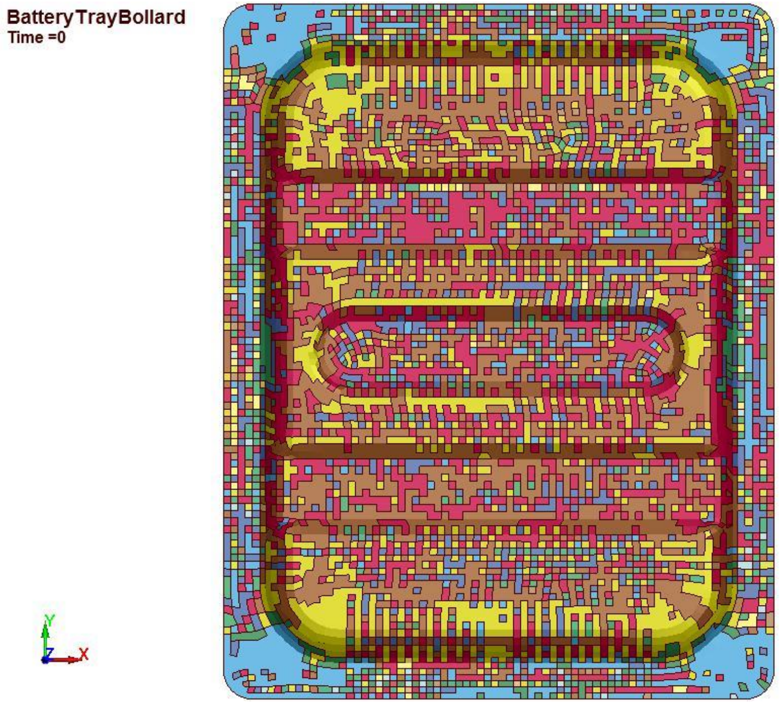
From Process to Performance

Battery Tray Bollard (Model)

Units					
MASS	LENGTH	TIME	FORCE	STRESS	ENERGY
Kg	mm	s	N	MPa	N-mm



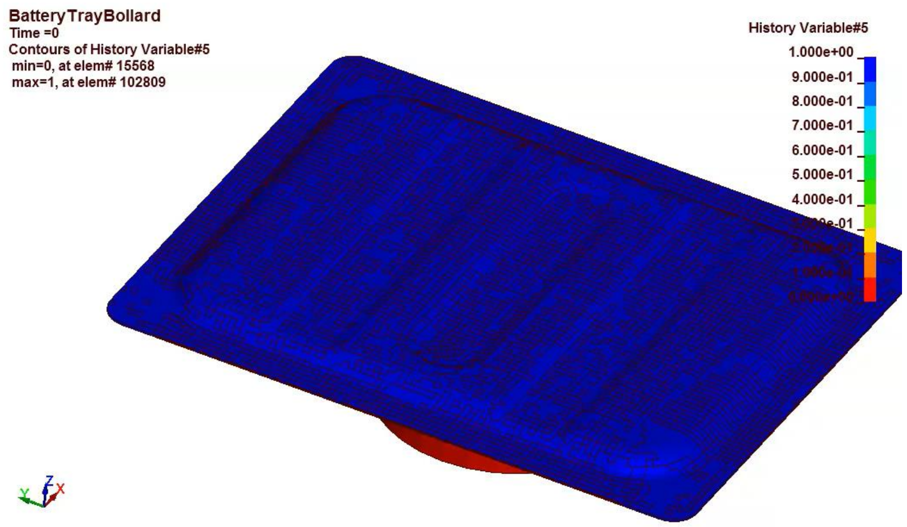


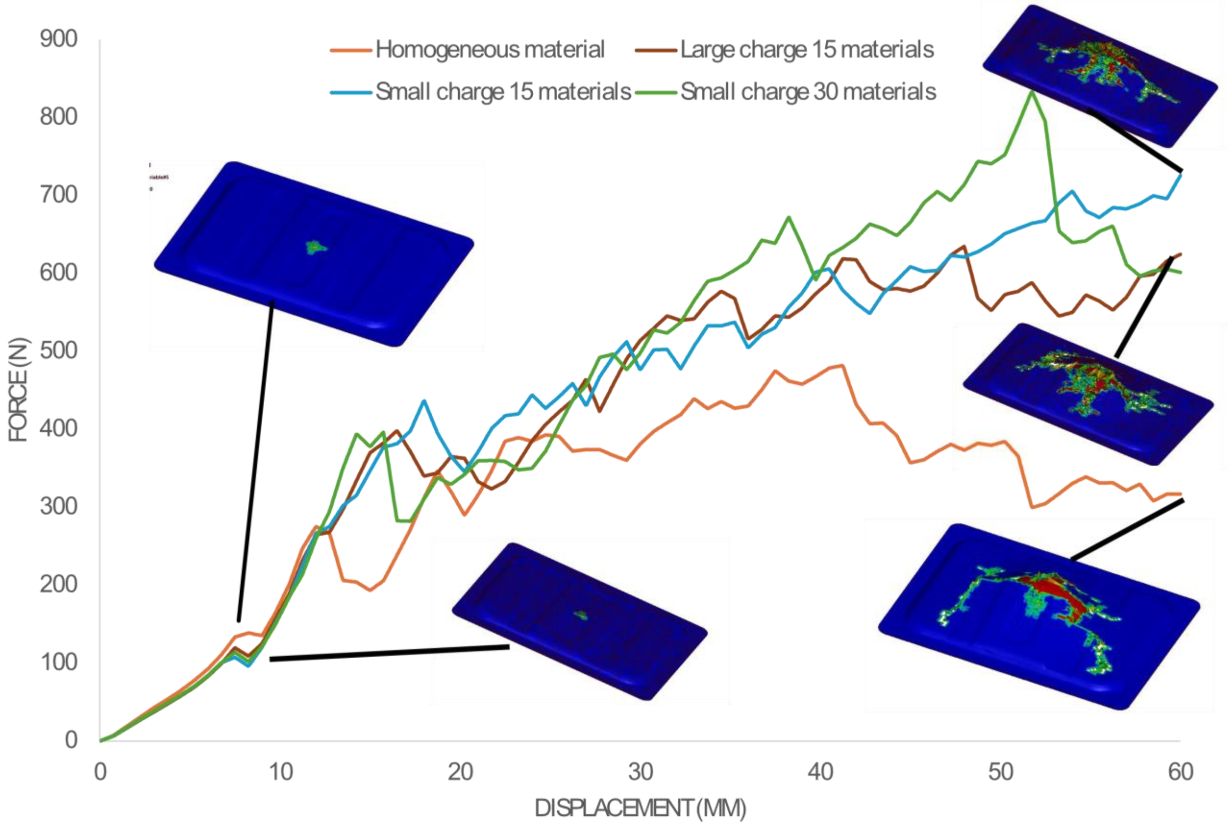


With different 15 materials

Results

Comparison between including manufacturing effect or not





Why rPET?

- rPET Processing Requirements

- Narrower and higher processing window (260°C -290 °C)
- More precise temperature control
- Needs fast transfer to avoid degradation and ensure quality forming.

- rPET Moisture Management

- Requires drying
- Otherwise hydrolysis and embrittlement during melt processing.

+ rPET Quality & Feedstock

- High availability
- Strong circularity : low degradation with recycling
- Advanced chemical recycling methods (depolymerization).
- High quality feedstock

rPP Processing Advantages

- Easier processing with a wider thermal window
- Lower energy consumption

+ rPP Quality & Feedstock

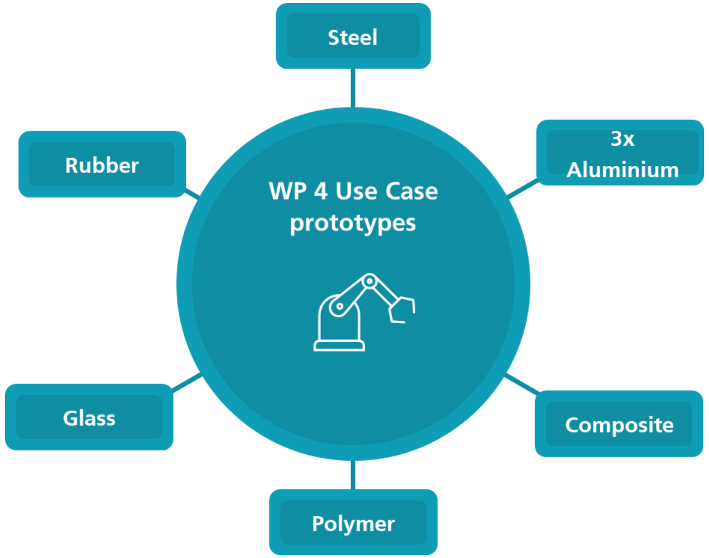
- Virgin material is cheaper - less drive for recycling
- Very varied sources
- Contaminates
- Quality variability
- Mechanical recycling – cheaper but lower quality
- limits use in high-value applications.

Conclusion

- Viscosity characterisation enables predictive process simulation
- Pragmatic viscosity model required for stable simulation
- Process → structure → performance link tested (load-case dependent)
- Recycled GMT viable for structural applications despite processing sensitivity
- rPET offers strong circular potential but requires tight process control
- Digital tools lower the barrier to adoption of recycled materials

Conference organised by ZEVRA

- Open to all
- User case will be presented



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ZEVRA

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