

# Numerical Modelling of Defect Evolution in Resin Impregnation Processes Using Virtual Manufacturing Tools

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## Motivation

The socio-economic goal of this research is to advance the understanding and simulation of composite manufacturing processes, while also providing practical improvements to industries. Accurate defect prediction and real-time process optimization will minimize material waste and the need for trial-and-error approaches, leading to faster and more efficient production cycles.

The development of novel methodologies for the design will pave the way for:

- Systematic **implementation of design for manufacturing** and certification principles enabling a more efficient concurrent structural component development characterised by time-to-market and development cost reductions.
- Integration of digitalisation and virtual material characterisation and testing within preliminary design methodologies in an attempt at **reducing expensive redesign loops** and sub-optimal stiffness distribution adjustments.

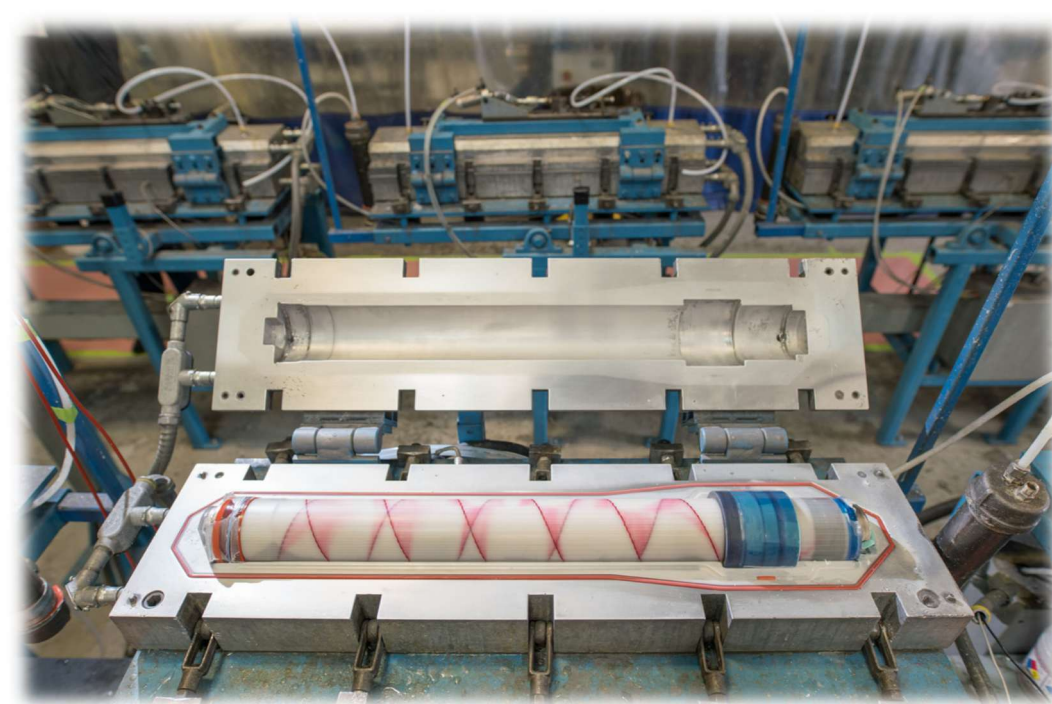
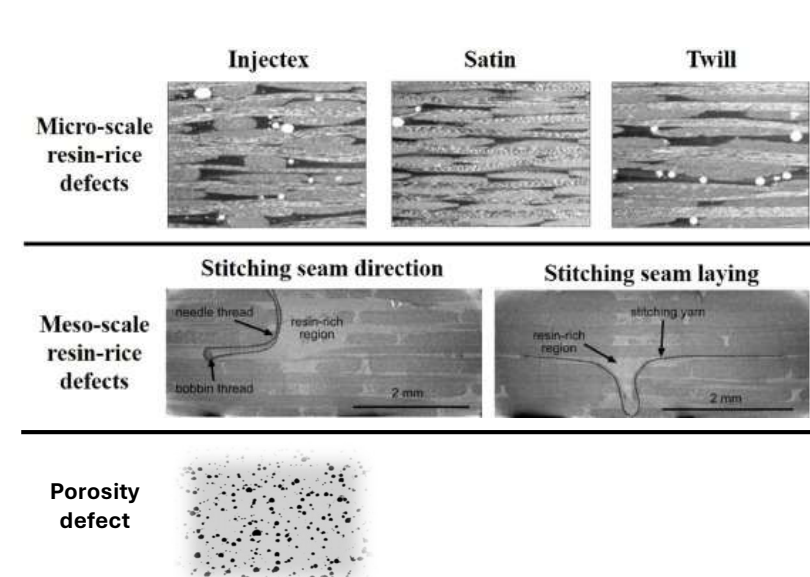


## Objectives

### Foreseen Results

- Implementing **design for manufacturing** strategies reducing the risks of **non-compliances**, through an accurate **defect prediction** [1].
- Integration of structural and certification constraints into the **optimization methodology**.
- Shortening composite material **lead time** and **time-to-market**.

### Manufacturing



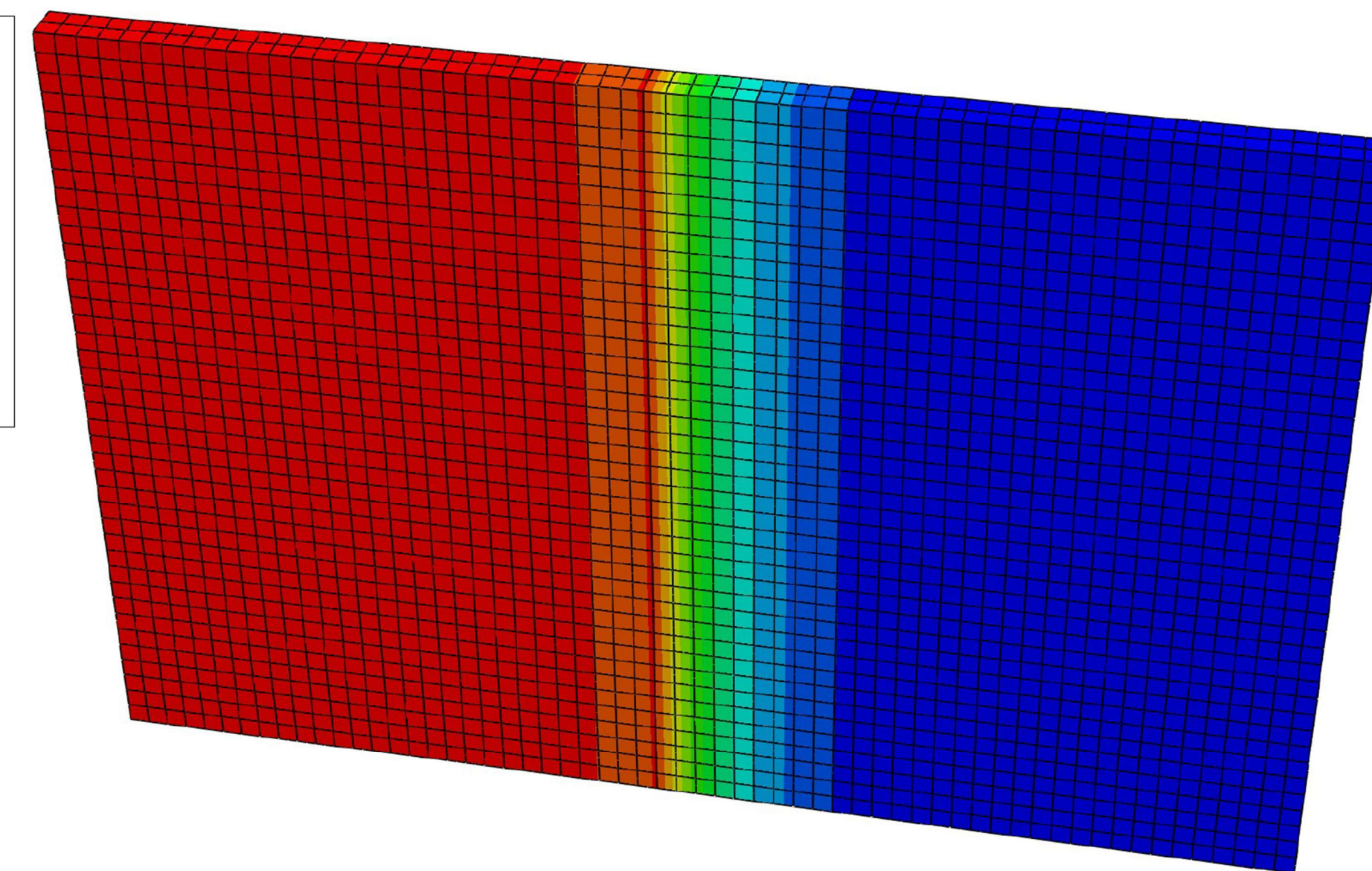
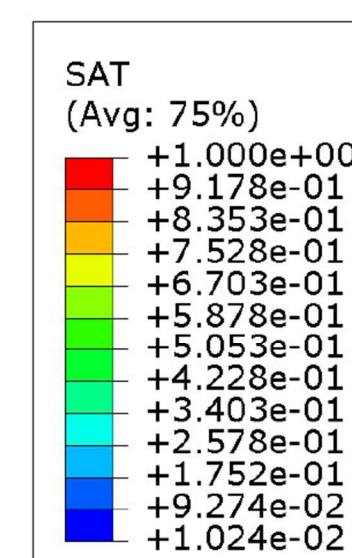
### Numerical Model

#### Digital Object After Manufacturing

Development of a numerical Finite Element Model of composite materials:

- Saturated Porous Media [2]
- Curing Polymerization [3]
- Bubble nucleation [4]
- Heat transfer

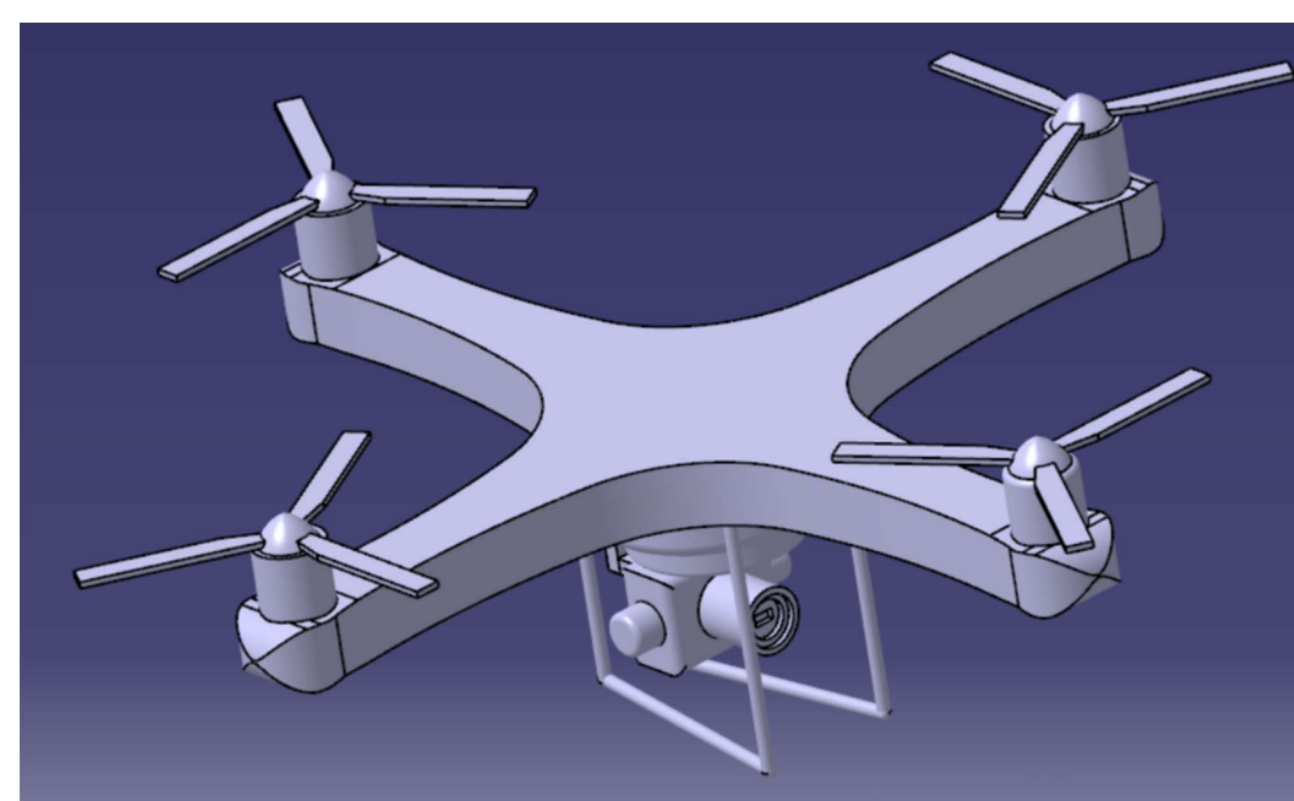
Introduction of coding for customization



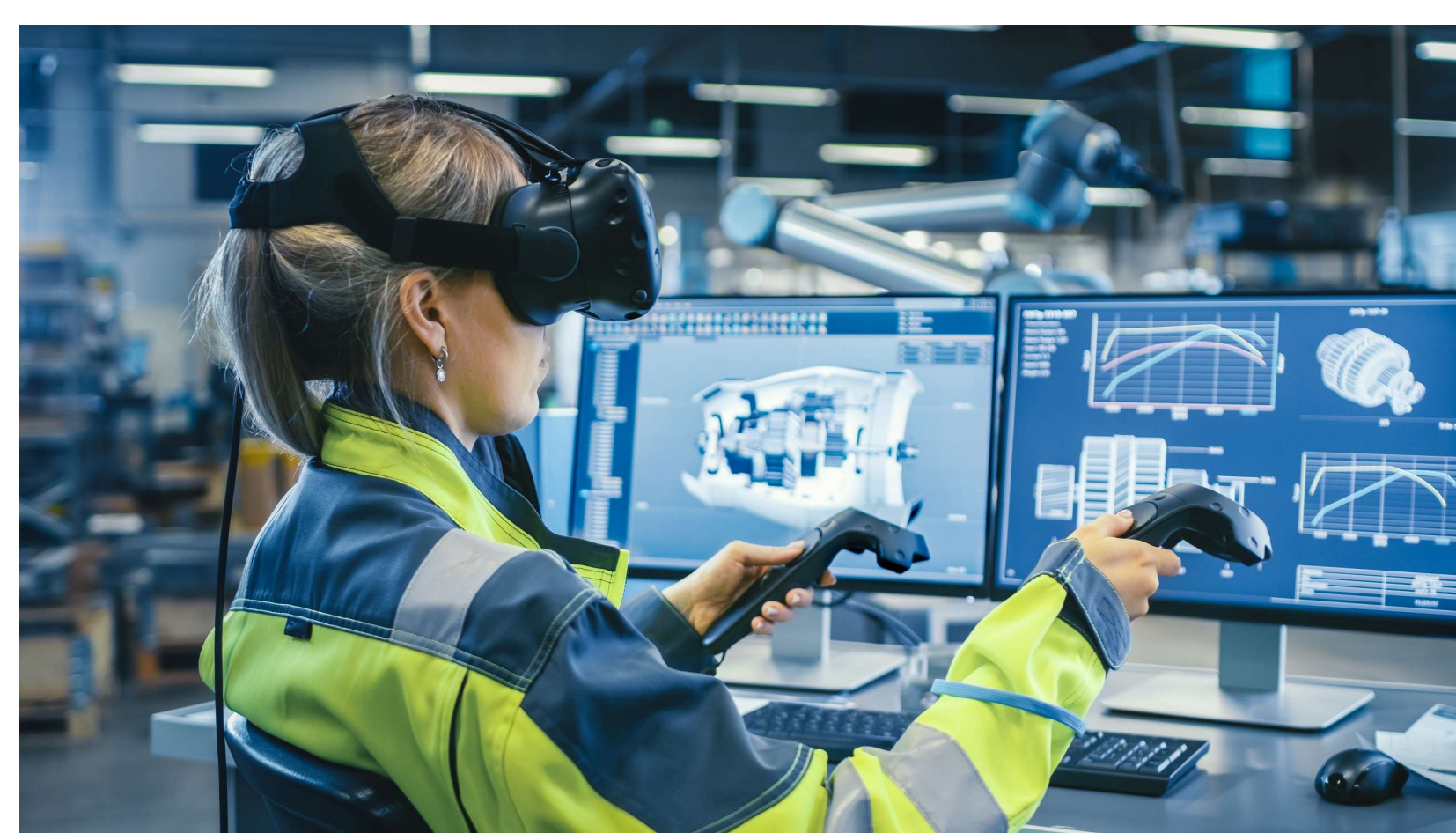
### Optimized Manufacturing

Identification of process parameters that most significantly affect the manufacturing process, reducing expensive redesign loops.

### Digital Object



### Virtual Manufacturing



## Methodology

### General features:

- Filling/Injection [5]
- Curing
- Springback
- Cooling down

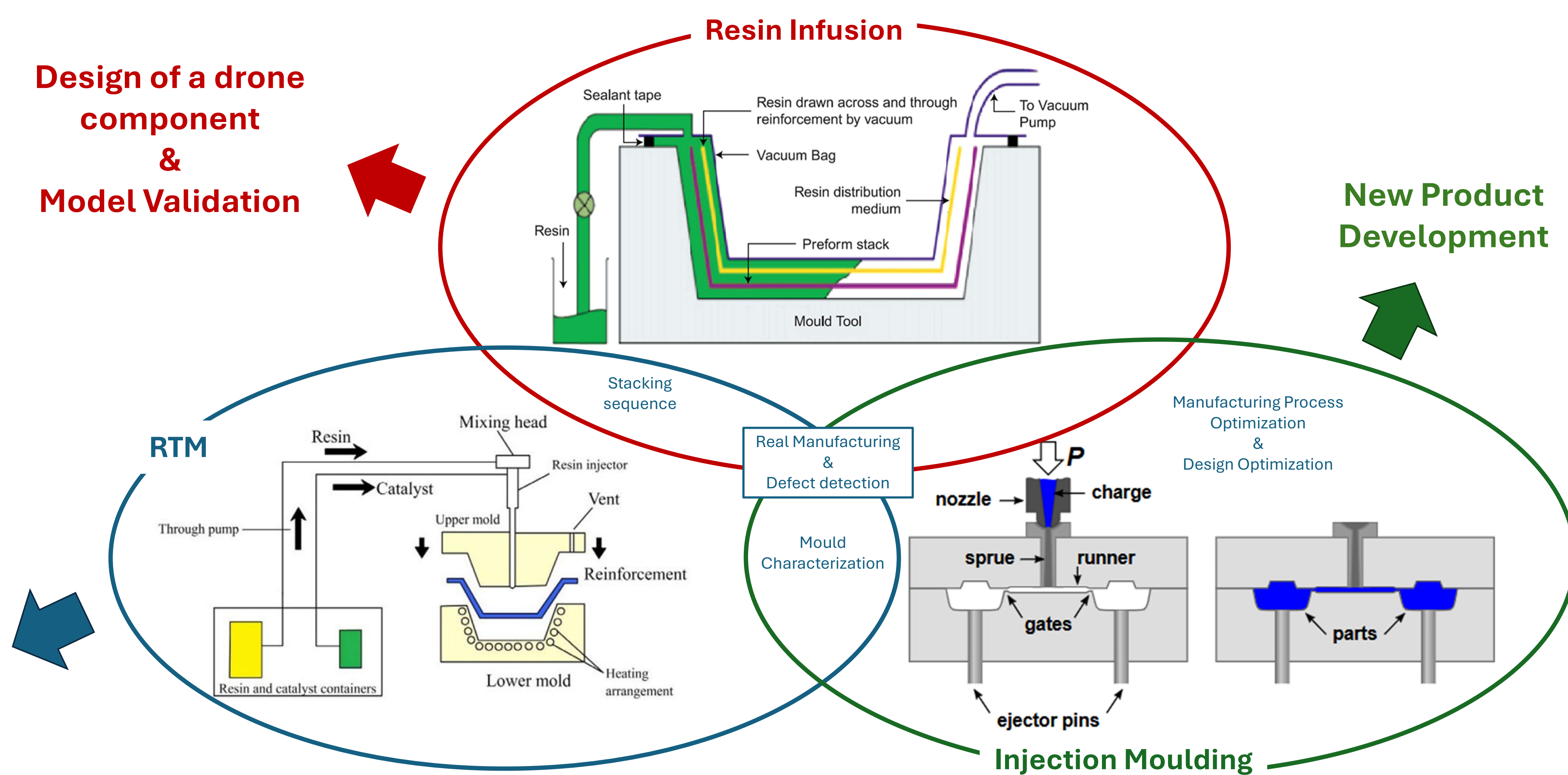
### Processes:

- RTM – Resin Transfer Moulding
- Resin Infusion
- Injection Moulding

### DoE

A Design of Experiment (DoE) will be generated to produce data set such as process parameters, outputs and defects origins. This data could be used for different future developments.

### Design of a drone component & Model Validation



## References

- [1] Ruiz, Achim, Soukane, Trochu, Bréard, *Optimization of injection flow rate to minimize micro/macro-voids formation in resin transfer molded composites*, Elsevier, Composites Science and Technology 66, pp. 475-486, 2006
- [2] Liang, Liang, *A user-defined element for dynamic analysis of saturated porous media in ABAQUS*, Elsevier, Computers and Geotechnics 126, 103693, 2020
- [3] Javdanitehran, Berg, Duemichen, Ziegmann, *An iterative approach for isothermal curing kinetics modelling of an epoxy resin system*, Elsevier, Thermochimica Acta 623, pp. 72-79, 2016
- [4] Blander, Katz, *Bubble nucleation in liquids*, AIChE journal 21, pp. 833-848, 1975
- [5] Maung, Malysheva, *Study of the effect of permeability coefficients in a three-dimensional formulation for fabrics various types of fabric structures*, Material Science and Engineering 683, 012082, 2019