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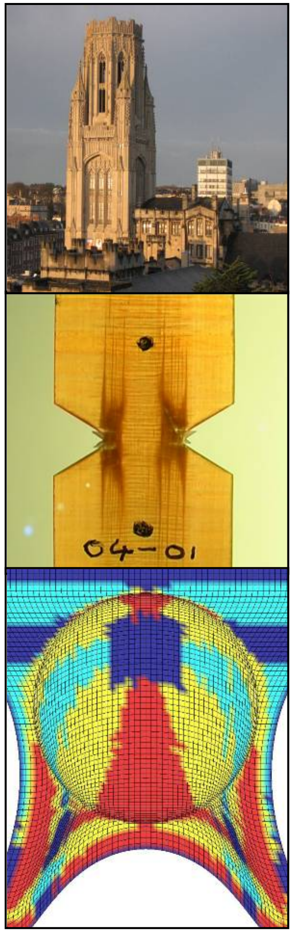

Towards a Design for Manufacture capability in composites

- tying together manufacturing research to maximise impact

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Why do we still, after more than 40 years, have problems in getting our designs into robust, high yield, right first time manufacture, on schedule, and with with low and predictable costs?

Why do we still, after more than 40 years, have problems in introducing new or improved manufacturing processes into industrial production to overcome some of these limitations?

I think that the answer is the same in both cases.

We lack an integrated understanding of the design and manufacturing processes – that understanding is what we might define as Design for Manufacturing or DfM.

What are the requirements for a DfM capability?

DfM requires an integration of our understanding related to:

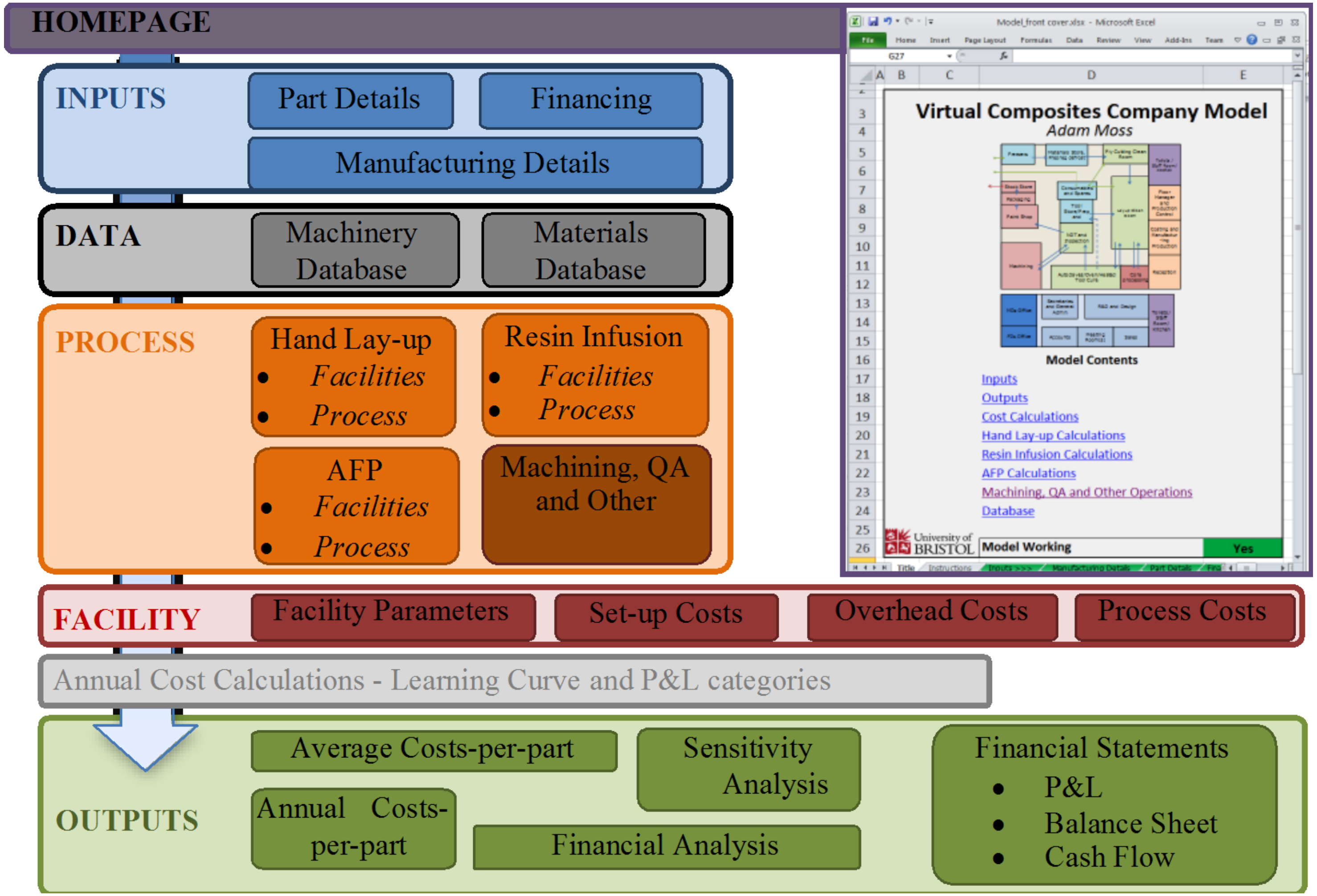
- ✧ product and structural design
- ✧ materials responses both in-process and as-moulded
- ✧ machinery design
- ✧ programming and operations
- ✧ metrology and NDT
- ✧ skills and training
- ✧ effective automation
- ✧ factory operations

The critical “glue” that holds together any effective DfM structure is the ability to cost the implications of design decisions.

We are now trying to move towards a DfM framework to support and inform our manufacturing research

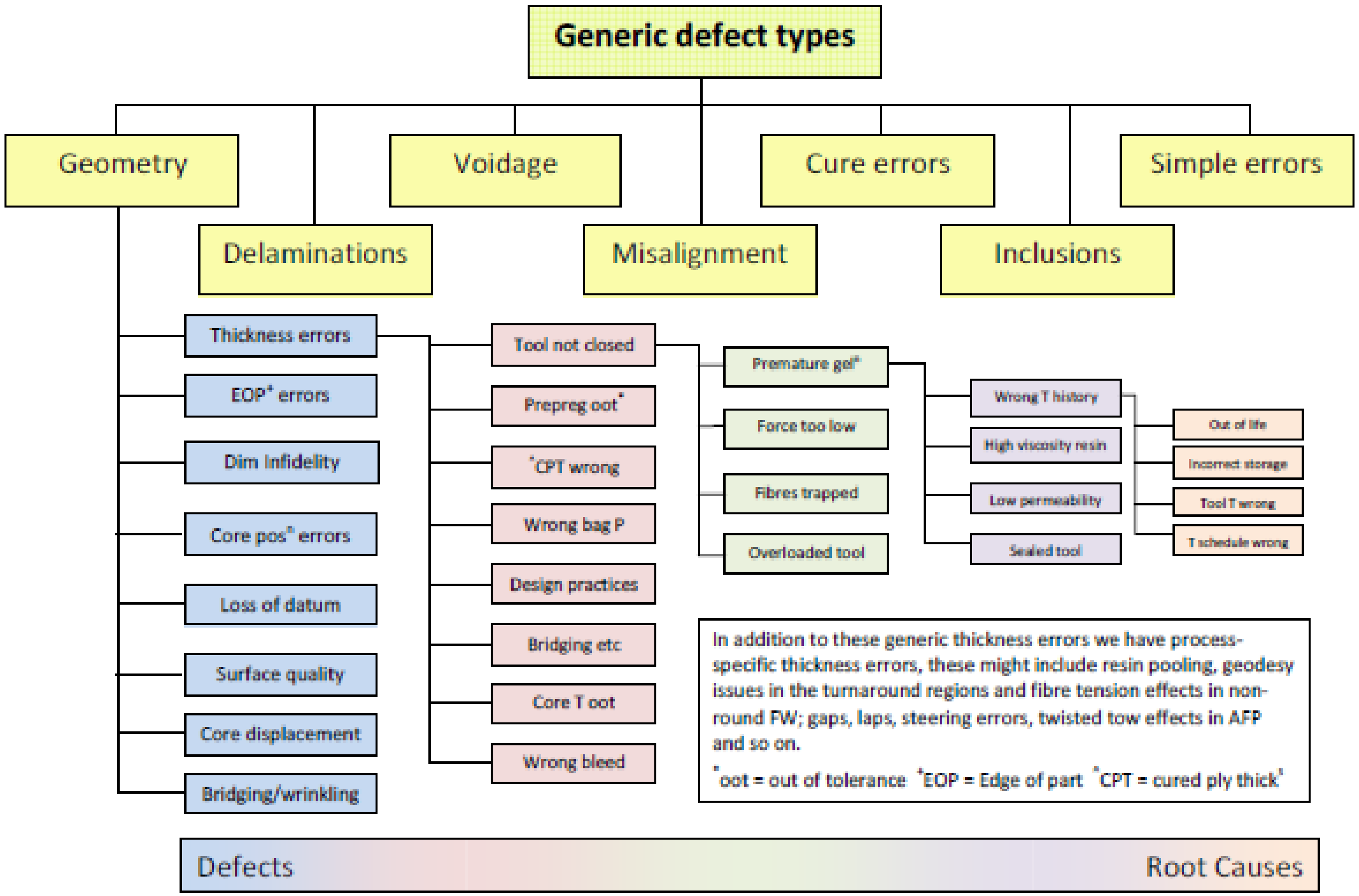
Understanding current methods 1. Costing

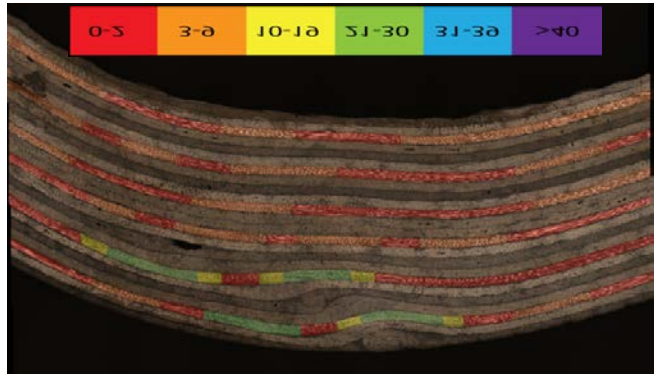
We have built a cost model for research and teaching, which is in effect a Virtual Composites Company that allows us to investigate multiple effects and how they interact

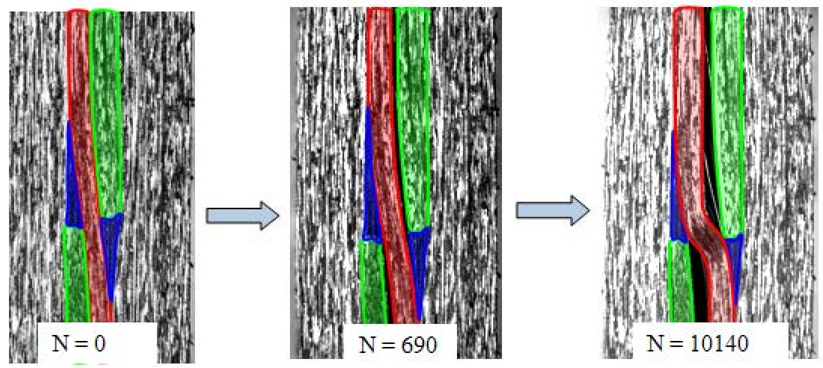


Understanding current methods 2. Defects

We study the origins, impacts and taxonomy of defects, with the aim of designing them out of our structures

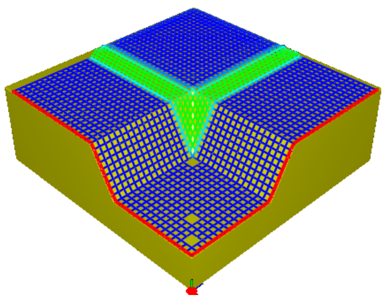


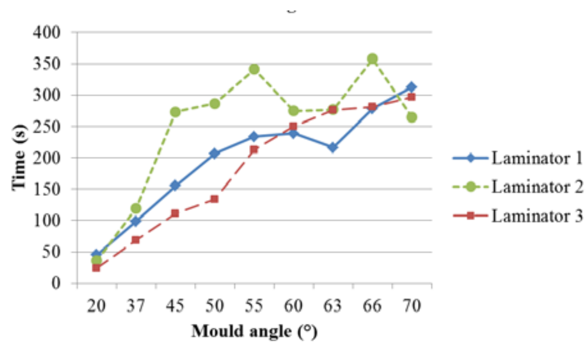


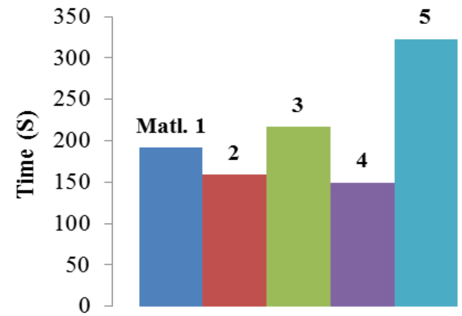


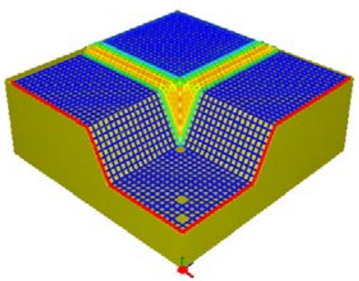
Understanding current methods 3. Lay-up

We are aiming to understand the impact of geometry, reinforcement properties and the techniques used, on manual lay-up time and quality, and to support process automation









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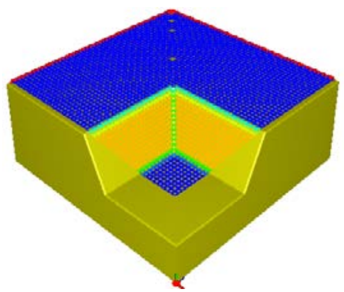
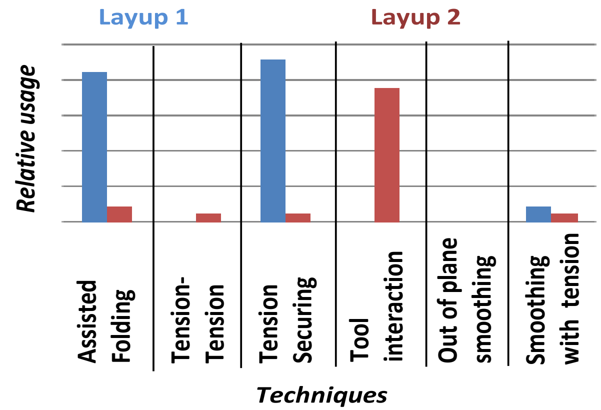


Lay-up 1

Lay-up 2



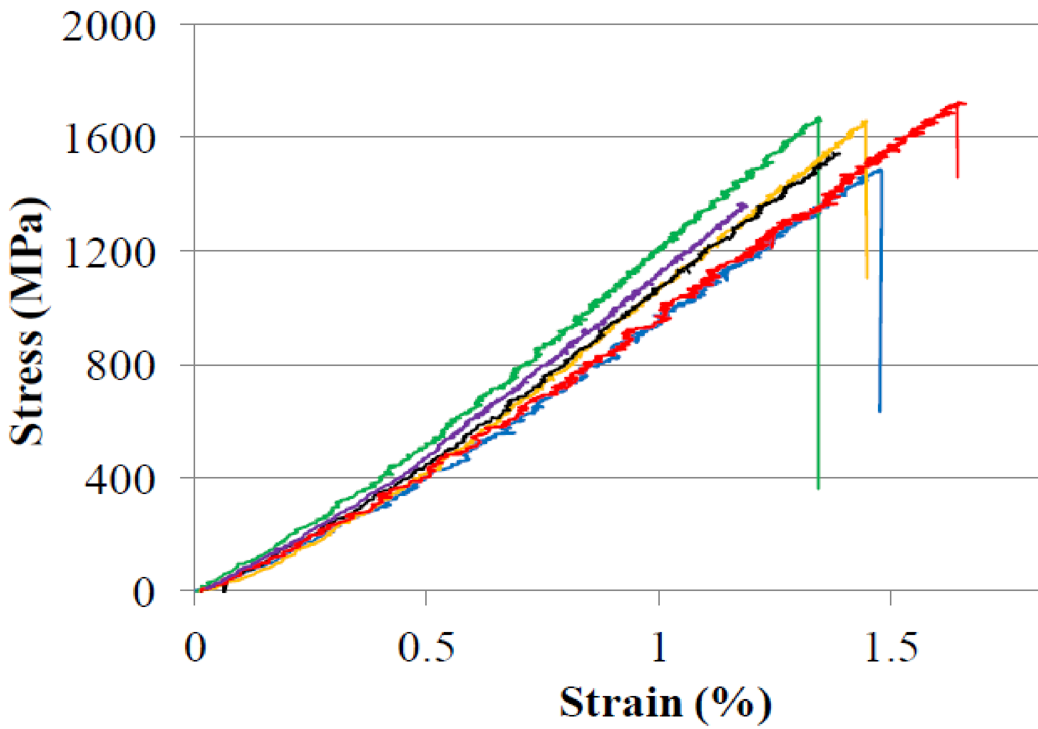
Understanding current methods 4. Design.

- We have just completed a set of interviews of people working at the design/manufacture interface in a range of companies. These people tend to take a design “guru” role.

- Average experience was >30 years, range 15 - 40 years.
  - People will be retiring from this group faster than they are recruited
  - It will be very difficult to grow the expertise base to support the growth in demand
  - Growth into new sectors increases the difficulty
  - Fragmentation of supply chains makes it even worse
  - We might actually be facing a decline in the numbers of widely experienced composites professionals with expertise from design through to factory operations

Developing new methods 1. HiPerADFP

A novel approach to the manufacture of very well aligned short fibre reinforcements is being developed that offers very interesting opportunities in carbon fibre recycling and hybridisation. This work is at an early stage of development, but has great potential



Mechanical properties are very similar to those of continuous fibre composites but the new process offers significant advantages in manufacturability and reduction of ply drop stress concentrations

Developing novel methods 2. ACTS

Advanced Continuous
Tow Shearing

A novel approach to advanced AFP is being developed that uses Tow Shearing rather than Tow Steering to improve the flexibility and performance of AFP. Using the new technique the minimum radius of curvature in the tow can be reduced by more than 90% without introducing defects, and gaps and overlaps can be minimised.

Bringing together the HiPerADFP and ACTS technologies could really revolutionise the capability of AFP.

Other current and recent research topics. 1.

- Automated backing film removal
- Batch of one design and manufacturing issues
- Design of novel composite structures for demanding applications (KTP)
- Gesture control of drape simulation – improving the potential for virtual collaboration
- High temperature composites >700^{o}C
- Honeycomb panel repair using ALM
- In-process inspection
- Industrialisation of composite wing spar structures
- Ink jet printing of conductive tracks

Other current and recent research topics. 2.

- ✧ Jointing of composite structures
- ✧ Manufacturing issues for multifunctional composites
- ✧ Novel approaches to binding/fixing 3D fabric geometry
- ✧ Novel controllers for automation equipment
- ✧ Pad printing for automating lay-up
- ✧ Pick and place end effectors and grippers
- ✧ Recycling of in-process waste into crash tubes
- ✧ Simulation of the AFP lay-up process
- ✧ Spring-in of sandwich panels
- ✧ Z direction reinforced structures

Conclusions and a way forward

- In collaboration with our industrial partners we need to understand better the limitations of current technology and how design decisions impact on cost and quality.

- In the short to medium term we need to use this knowledge to guide our research and ensure that the outputs emerging from that research can impact on current and future design requirements.

- In the longer term we need to ensure that the design practices reflect what it is possible to achieve now and in the future, to capture all the value possible in multifunctional and other novel composites as they emerge.