Forming of Complex Aerostructures for Next Generation Aircraft Wings

Claudia Jimenez Martin cj13633@bristol.ac.uk
Academic Supervisor: Dr James Kratz, University of Bristol
Industrial Sponsor: Turlough McMahon, Jon Wright, Airbus

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The next generation aircraft will require the production **of large, high-volume composite structures** to meet the demands of the aerospace sector. **Diaphragm forming** has been used for this study as a potential method for automating the production of preforms for high volume applications. The shift from traditional pre-impregnated materials to **dry Non-Crimp Fabrics** (NCF's) can allow higher **deposition rates** to meet **increased production targets**.

Problem Statement

The adoption of new materials and processes requires a robust pyramid of testing to obtain a high quality full scale component. Sub scale test results can be difficult to relate to the full scale. Quality assessment with the current means is also limited which can result in missing data to correlate between scales.

Aims & Objectives

The aim of this project is to assess the suitability of material characterisation and sub scale testing for predicting full scale preform quality.

To achieve this, three objectives at each scale of the pyramid of testing are proposed, all relating to improved data capture and testing, ultimately enabling a better understanding of NCF forming over complex aerostructures.

Current pyramid of testing limitations

Full scale wing forming
Forming over full scale wing geometry testing global features e.g. curvature

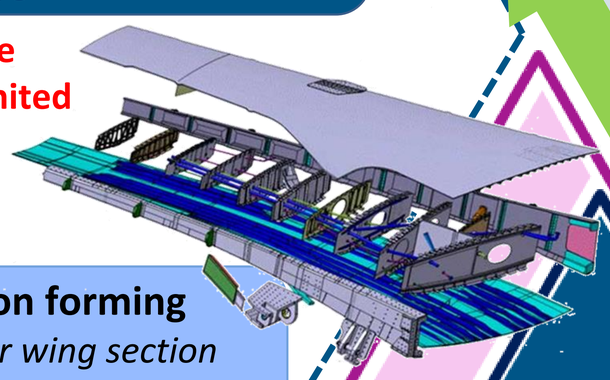
- **Data capture methods limited by full scale process**

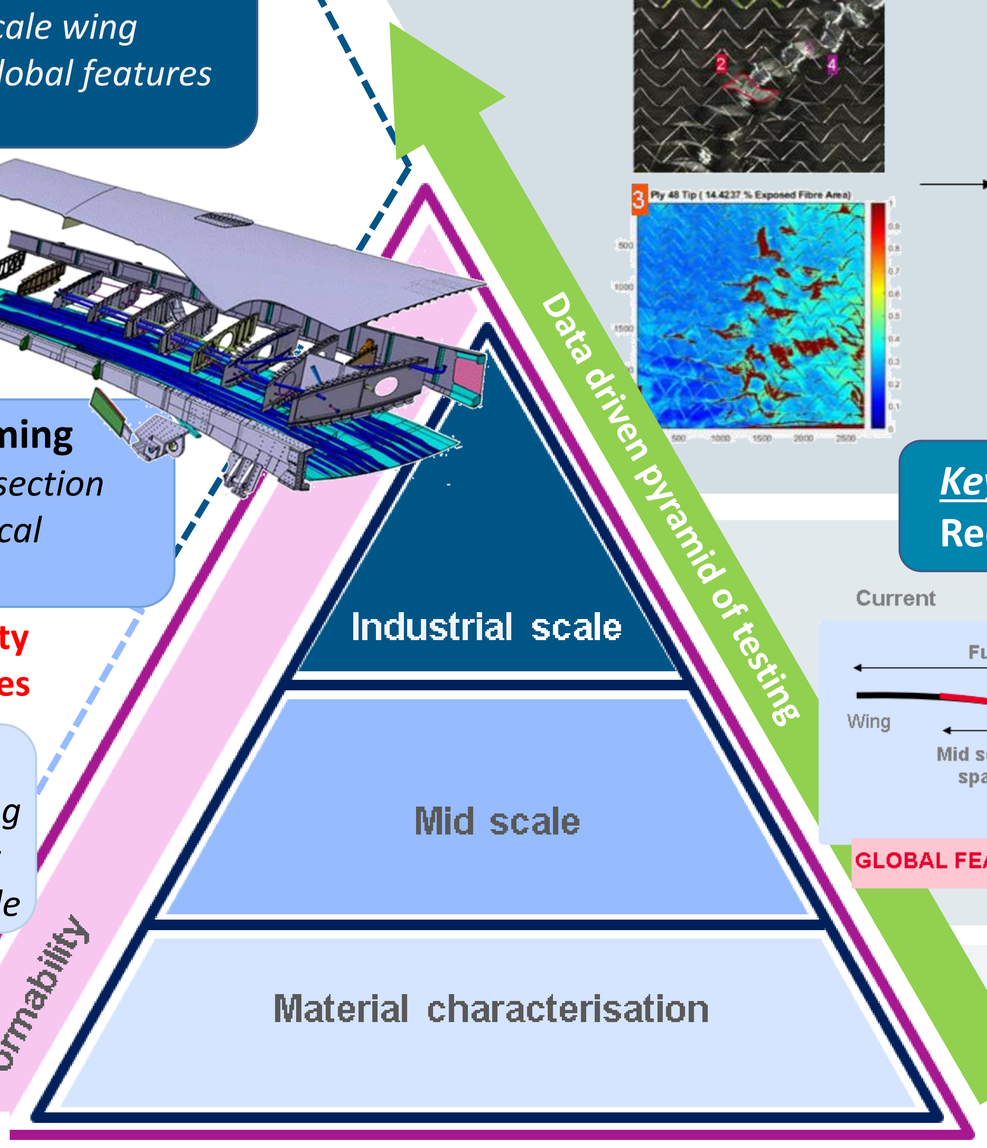
Wing section forming
Forming over wing section geometry testing local features e.g. ramps

- **Limited by scalability of geometry features**

Bias extension
Tensile test capturing force vs shear of dry fibre material sample

- **Inaccurate boundary conditions**





Key objective / INDUSTRIAL SCALE
Assess quality with data capture methods available

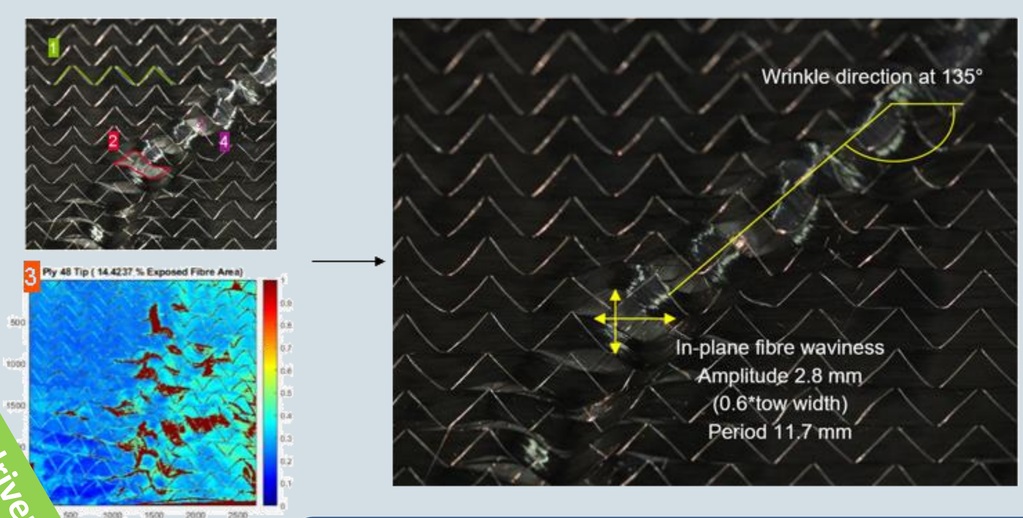


Figure 1. *High resolution cameras are used to capture defects from the full scale component. Image analysis can help extract numerical data for comparison to sub scale test quality. Analysis techniques include stitch tracking (1), fibre tracing (2),identification of tow gaps (3) and centroid tracking (4)*

Key objective / MID SCALE
Redesign a mid scale test geometry

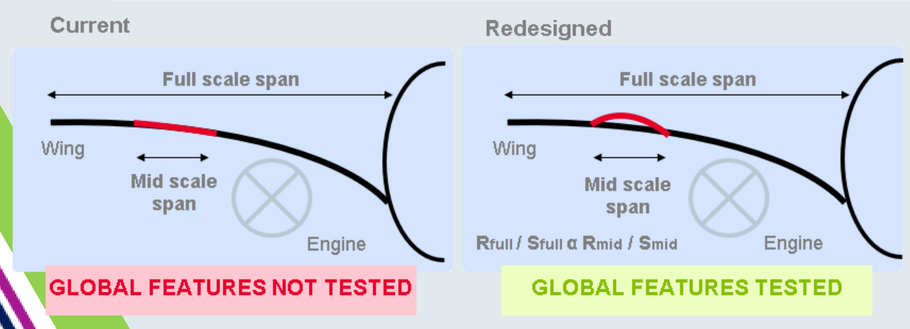


Figure 2. *Schematic showing geometry design principle for redesigned mid scale demonstrator. Curvature scaled by factor defined by span ratios between full and mid scale.*

Key objective/ MATERIAL CHARACTERISATION
Quantify effect of material parameters on formability

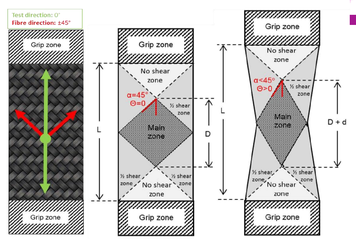
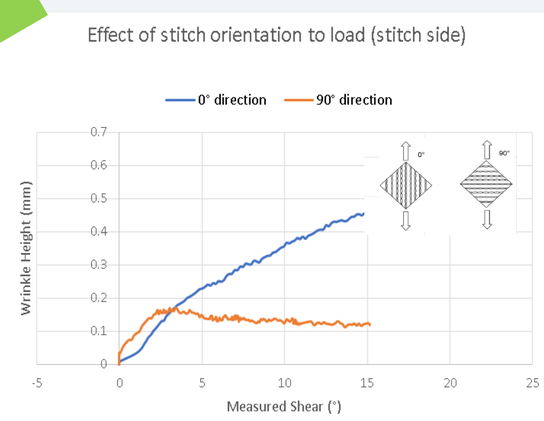


Figure 3. *Bias extension test set up used in Material Characterisation, showing shear zones predicted by Pin Jointed Net assumption*



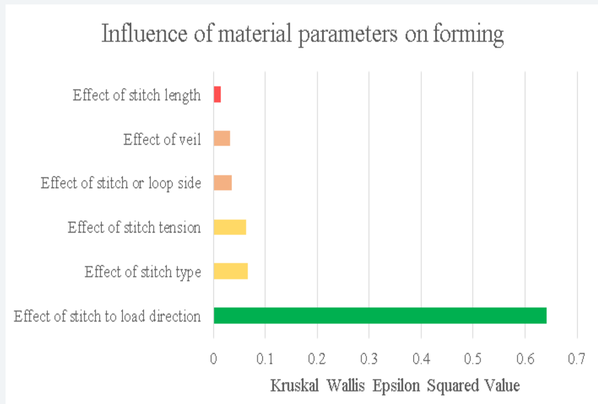


Figure 4. *Results from bias extension testing. Left: Wrinkle height vs measured shear plot with stitching at 0° and 90° to the load direction. Right: Statistical test evaluating the effect of material parameters on forming. Higher Epsilon Squared value signifies parameter has a higher influence on the forming result.*

Summary

The **pyramid of scale** shows issues relating to how the scales relate to and inform each other

To address this a **redesigned mid scale** demonstrator and a **data driven** pyramid of testing have been proposed

This can help inform which scale is most appropriate to de-risk the full scale component in a resource and cost competitive way

Ultimately enabling fast & repeatable preforming for future high production rate wings

Results

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