Bristol Composites Institute (ACCIS)

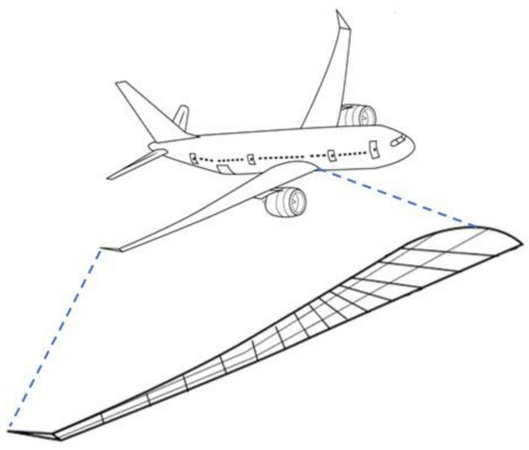
ADVANCED COMPOSITES COLLABORATION FOR INNOVATION & SCIENCE

Engineering and Physical Sciences Research Council

EPSRC Centre for Doctoral Training in Advanced Composites for Innovation and Science

A novel method for designing blended laminate composite structures

Noémie Fedon, Alberto Pirrera, Paul M. Weaver, Terence Macquart



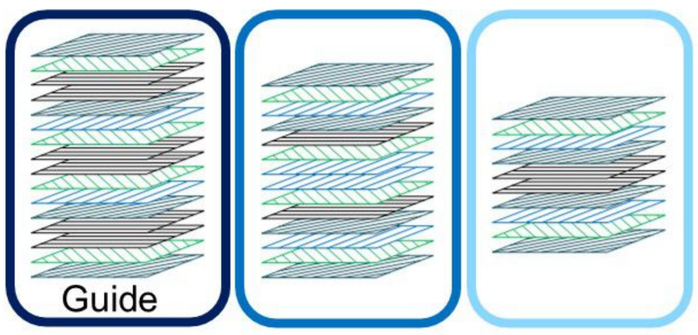
To reduce the weight of aerospace structures, the stiffness of composite laminate shells can be tailored by varying laminate thickness and ply fibre orientations. The process of designing each panel to fit harmoniously into the wing as a whole is known as *blending,* and is challenging because of two reasons. Firstly, there is a large number of discrete design variables to deal with, *i.e.* fibre orientations and ply drop positions. Secondly, the design of individual panels is constrained by many guidelines that ensure global geometric continuity, strength requirements and ease of manufacture.

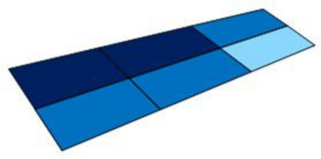
Current optimisation techniques for blending have several drawbacks. For instance, their tendency to convergence towards local sub-optimal designs and their speed, or lack thereof, especially for thick panels with many plies.

Principles of the novel blending technique

Blending methodology

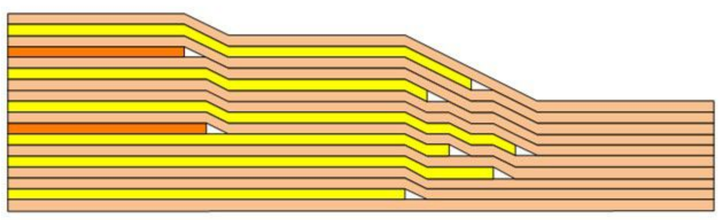
Guide-based blending: panels with the same thickness designed identically



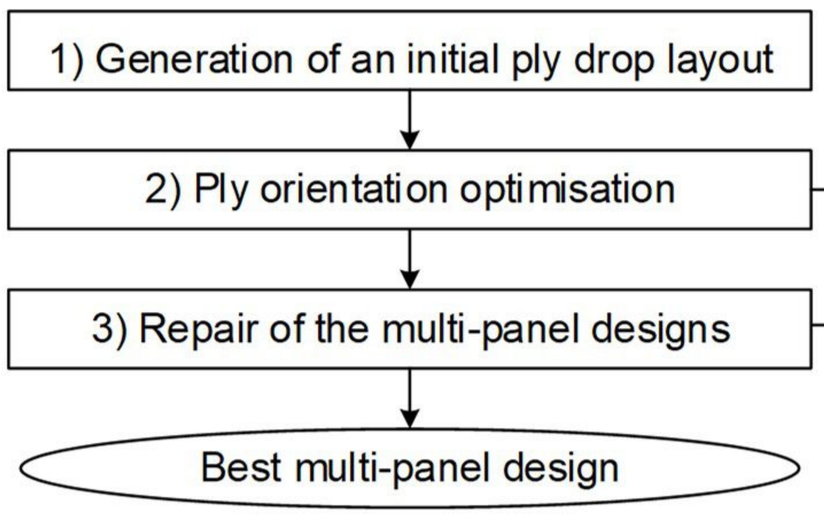


Reduction in the number of design variables and constraints

Greater-than-or-equal rule: all plies in a panel continue in adjacent thicker panels



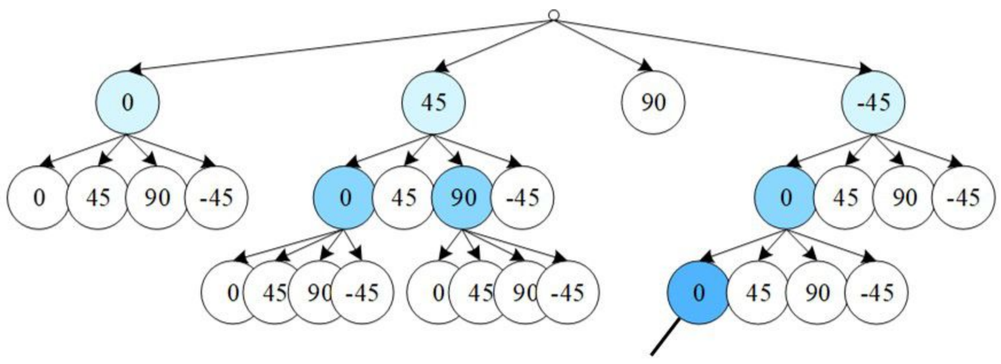
Optimisation procedure



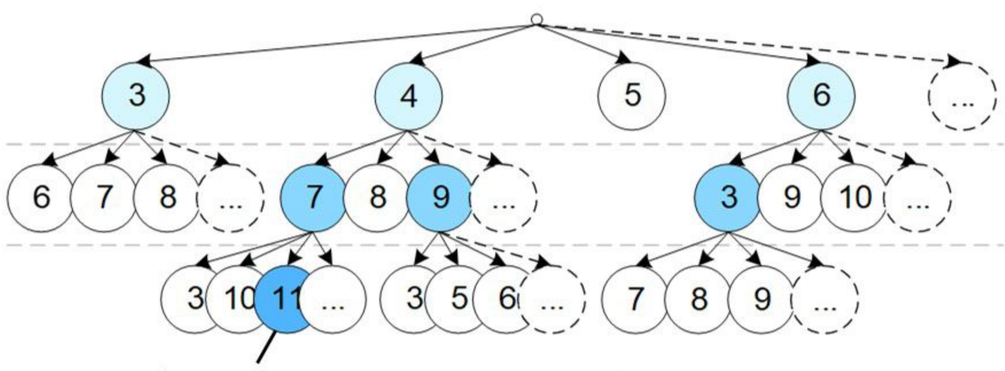
Main novelties

A novel procedure to create laminate layouts with ply drops almost uniformly distributed through the laminate thickness at panel boundaries, for minimal ply-drop interference.

A deterministic optimisation of the ply orientations with a beam search using novel heuristic cost functions for fast and controlled exploration of the laminate design space



A repair strategy to retrieve manufacturable multi-panel designs which includes a re-optimisation of the ply drop layout by a beam-search

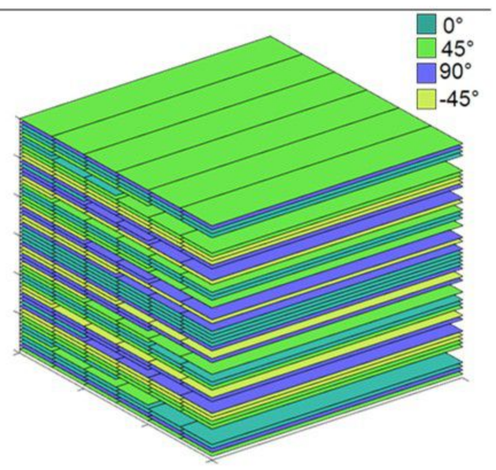


Results

Retrieval of the design for a structure with 6 symmetric panels of 60 / 56 / 52 / 48 / 44 / 40 plies

Design obtained in less than a minute with the following guidelines considered: symmetry, balance, contiguity, disorientation, 10% rule, ply-drop spacing rule and ply-drop stacking rule

Lamination parameter results: average error 3.6% and worst error around 15%



bristol.ac.uk/composites