University of BRISTOL

accis
ADVANCED COMPOSITES CENTRE FOR INNOVATION & SCIENCE

A New Optimisation Framework for Investigating Wind Turbine Blade Designs

T. Macquart, D. Langston, A. Pirrera and P. M. Weaver

This project investigates the potential of blade bend-twist coupling (BTC) as a means of reducing loadings and therefore the Levelised Cost of Energy (LCoE) for wind turbines. A dedicated framework enabling the aero-elastic analysis and optimisation of wind turbines has been developed, and will be used to explore the relative merits of BTC. This framework is capable of efficiently analysing arbitrary blade planforms and material layups so that BTC can be introduced through both geometrical blade sweep and material anisotropy.

Aim – The aim of the proposed framework, illustrated in Fig. 1, is to provide a single design and optimisation tool which describes in a compact manner the variations of structural properties along the blade span while performing the ensuing aero-elastic analyses. Furthermore, the framework will be employed to explore the wind turbine design space and evaluate the performance of non-conventional designs against standard blade designs.

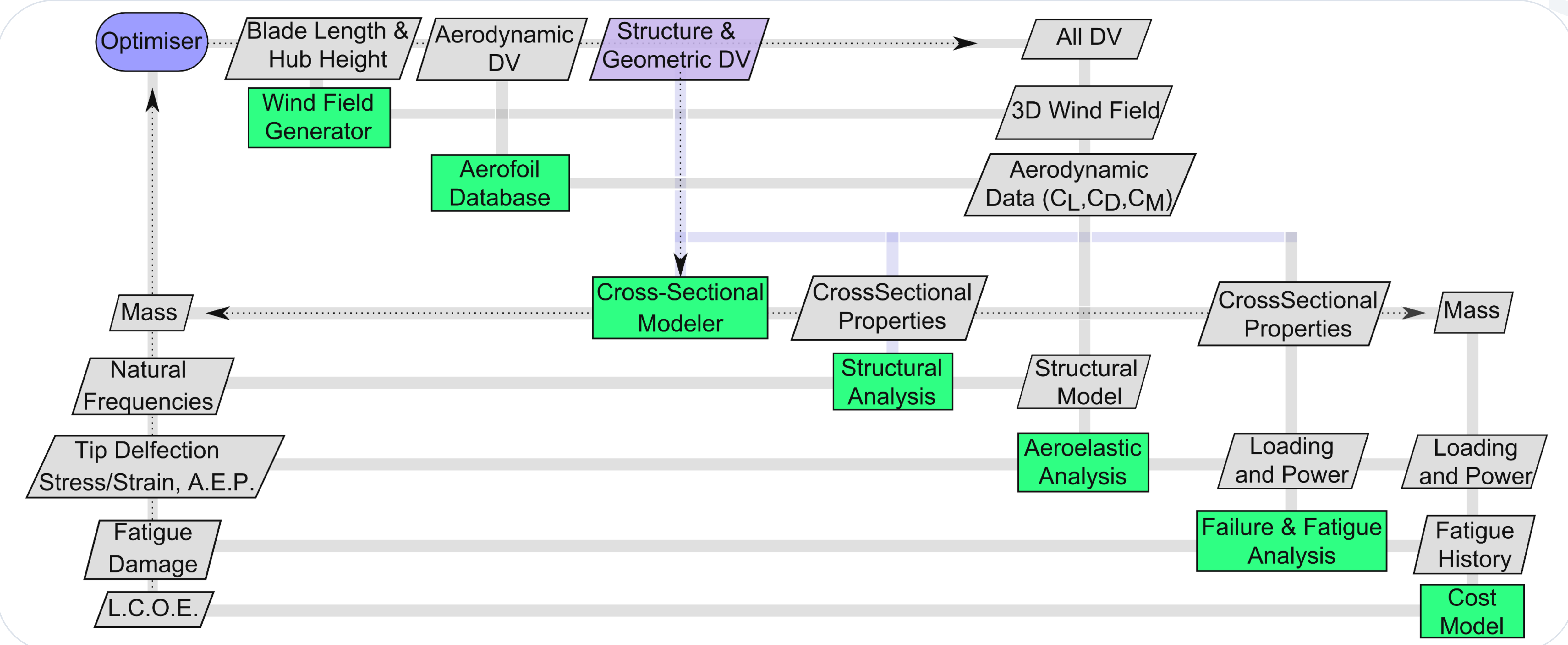
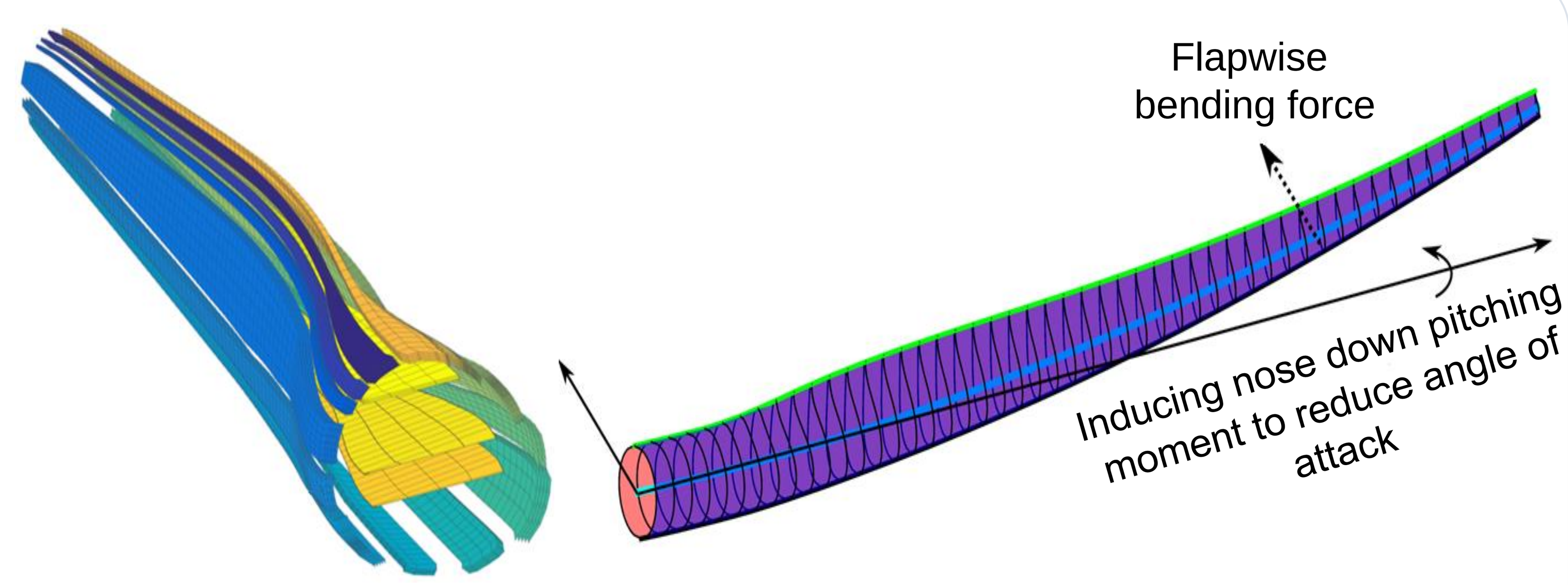


Fig. 1 - Block diagram of the proposed multidisciplinary optimisation framework
Design Variables = DV, AEP = Annual Energy Production

This optimisation framework has required the development of specific tools and methods such as:

1) An efficient structural parameterisation based on lamination parameters* and B-splines illustrated in Fig. 2 which significantly reduces the number of design variables and results in a continuous design space enabling the use of gradient based optimisers.

2) A beam model that captures the spanwise variations of structural properties and accurately predicts BTC mode shapes.



A) Structural Parameterisation of Material Distribution
B) Geometrically Induced Twist via Sweep

Fig. 2 – Structural Parametrisation and Geometrical Sweep

Future work planned for this year include aero-elastic validations and design space exploration to establish which BTC concepts have the greatest potential for LCoE reductions.

*Lamination parameters are a computationally efficient, analytical tool that enable the stiffness properties of an arbitrary laminate to be quantified through 16 parameters only. With careful constraint they also ensure that the resulting laminate is realistic/manufacturable.

Supported by
www.bristol.ac.uk/composites
SUPERGEN WIND
EPSRC
Engineering and Physical Sciences Research Council