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PROGRESS AND CHALLENGES IN THE VIRTUAL TESTING AND DESIGN OF COMPOSITE STRUCTURES

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Summary: The emergence of the 'all-composite' wide-body passenger aircraft represents a quantum leap in the utilisation of carbon-fibre composite material. With Boeing and Airbus both claiming substantial weight savings over comparable aluminium airframes, leading to commensurate savings in fuel consumption; superior corrosion and fatigue resistance, and reduced maintenance requirements for the operators, composites are likely to continue to feature prominently in future airframe development programmes. Moreover, the increasingly stringent environmental targets, being proposed by various intergovernmental organisations, will further drive these weight reduction efforts.

Nonetheless, the development of carbon-fibre aircraft has incurred high development costs, slow production rates and lengthy and expensive certification programmes. The effective use of modelling and simulation at all levels of the production development cycle offers the potential for improving development and production efficiencies and consequently increasing competitiveness. While the aerospace industry has been at the forefront of the use of associated technologies, with a knowledge base developed over many decades and focussed on the design, manufacture and testing of metallic airframes, the modelling of composite structures has highlighted the inadequacy of existing simulation tools to reliably predict their behaviour.

The development of the Boeing 787 and the Airbus A350 propelled the certification authorities into unfamiliar territory, owing to the limited in-service experience of composites in primary aerostructures. Indeed, the FAA (and EASA) each applied a number of additional conditions towards the certification of the Boeing 787 (and the Airbus A350) where it was deemed that the current airworthiness standards were not adequate to ensure that composite primary aerostructures provided the same level of safety as their metallic counterpart. The building block approach which forms the basis of current experimental programmes and usually represented by a Rouchon test pyramid, is costly and time consuming. Certification by simulation offers the potential for significantly reducing the extent of physical testing. This plenary lecture will focus on the progress and challenges in the development of simulation tools for the design and analysis of composites structures, with an emphasis on the work done by the presenter's research group in predicting impact damage, residual strength and energy absorption for crashworthiness assessments. The lecture will also discuss some of the obstacles which must be overcome if certification by simulation is to form a part of the development cycle.