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ENHANCED DAMAGE TOLERANCE ALLOWABLES FOR IMPROVED COMPOSITE WING SIZING

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Aircraft design, particularly in the preliminary phase, requires damage tolerance (DT) considerations as a part of the structural optimization. As early design phases do not allow comprehensive test campaigns or detailed numerical analysis, the conventional DT assessment methods limit the design space and restrict the DT strain allowable. We present an innovative method that incorporates DT into the composite structural optimization process, aligning with guidelines for damage-tolerant aircraft design according to a no-growth approach. Focusing on the ultimate load static strength requirements for barely visible impact damage of the damage category 1, we have developed a DT allowable calculation method that is both practical and robust while enabling the identification of additional load carrying potential.

The core of our approach is a DT assessment process that systematically calculates the DT allowable through a series of iterative minimization procedures. This process is built upon established methods for analyzing impact, detectability, and residual strength. The innovative aspect of our approach lies in its ability to provide laminate-specific DT allowables by iterating over damage-prone interfaces in a layup, relevant thicknesses for each ply share configuration, and preselected ply share configurations. This methodology not only ensures a comprehensive coverage of the design space but also allows for the derivation of the most conservative DT allowable for the sizing process.

Our findings demonstrate a significant increase in the DT allowable—up to 50%—for optimized sublaminate configurations where 0°plies are avoided in the outermost layers of a laminate stack, [1]. When applied to the multidisciplinary aero-structural design of a composite wing, this results in a potential wing mass reduction of 5%, translating to a fuel consumption decrease of approximately 1.4%. These results highlight the potential of incorporating DT considerations in early design stages for more efficient and sustainable aircraft designs.

In addition to a more reliable DT prediction, the evaluation of uncertainty during the design is of great importance. Therefore, the resulting deterministic design process is extended by a probabilistic analysis. The presentation gives an overview of the particular inclusion of uncertainties by means of distributed material properties, as developed within the European UP Wing project.

REFERENCES:

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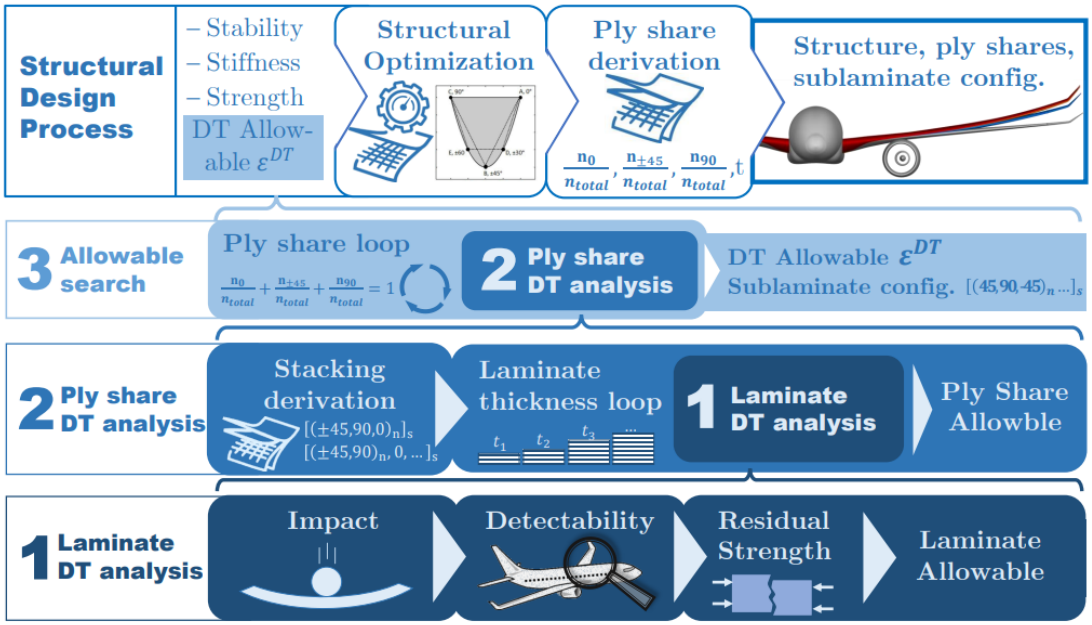

Figure 1: Schematics of the Damage Tolerance assessment to calculate the allowable for the structural design process.

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