Numerical Modelling of Thermoplastic Composite Fuselage Panels via Experimental Building Block Approach

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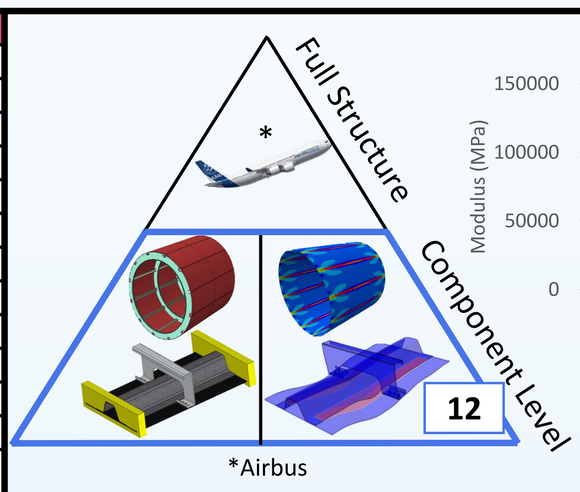
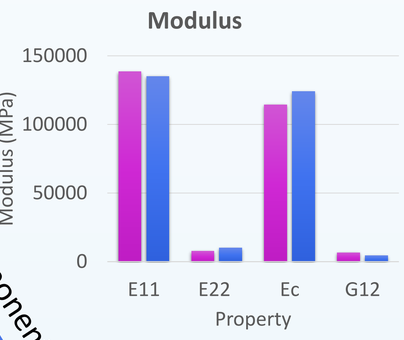
ABSTRACT

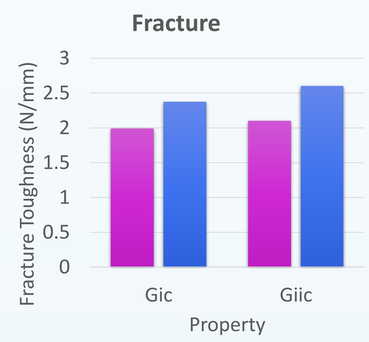
A building block approach [1-3] is used for design and verification of a multistiffener fuselage panel. On this moment, the 2 base levels of coupon levels (material & fracture characterization) and the element level (CAI, bearing) have been completed and numerical models have been calibrated. Currently, the calibrated properties are giving feedback for the design of the 3rd level of the pyramid, which is the component level. The comparison of the extracted properties to the product ones gave a significant deviation which comes mainly from different standards used. Moreover, in some cases Hashin damage model fails to describe the plasticity behavior of LMPAEK thermoplastic matrix composite material, like in the case of 10° off axis tension.

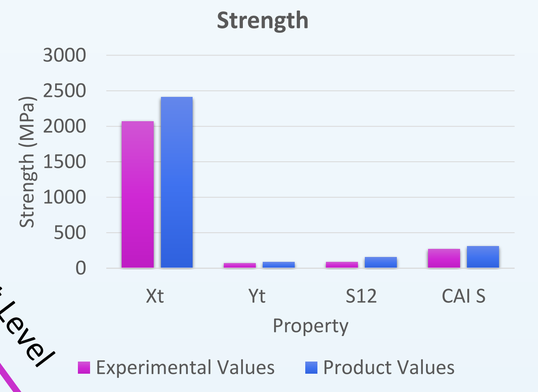
No	Experiment
1	Tension 0°
2	Tension 90°
3	Compression 0°
4	Fracture Mode I
5	Fracture Mode II
6	Shear 10° Off Axis Tension
7	Low Velocity Impact
8	Compression After Impact
9	Bearing
10	Bearing Failure
11	Fastener Pull Through
12	Mousehole Compression

*Ongoing



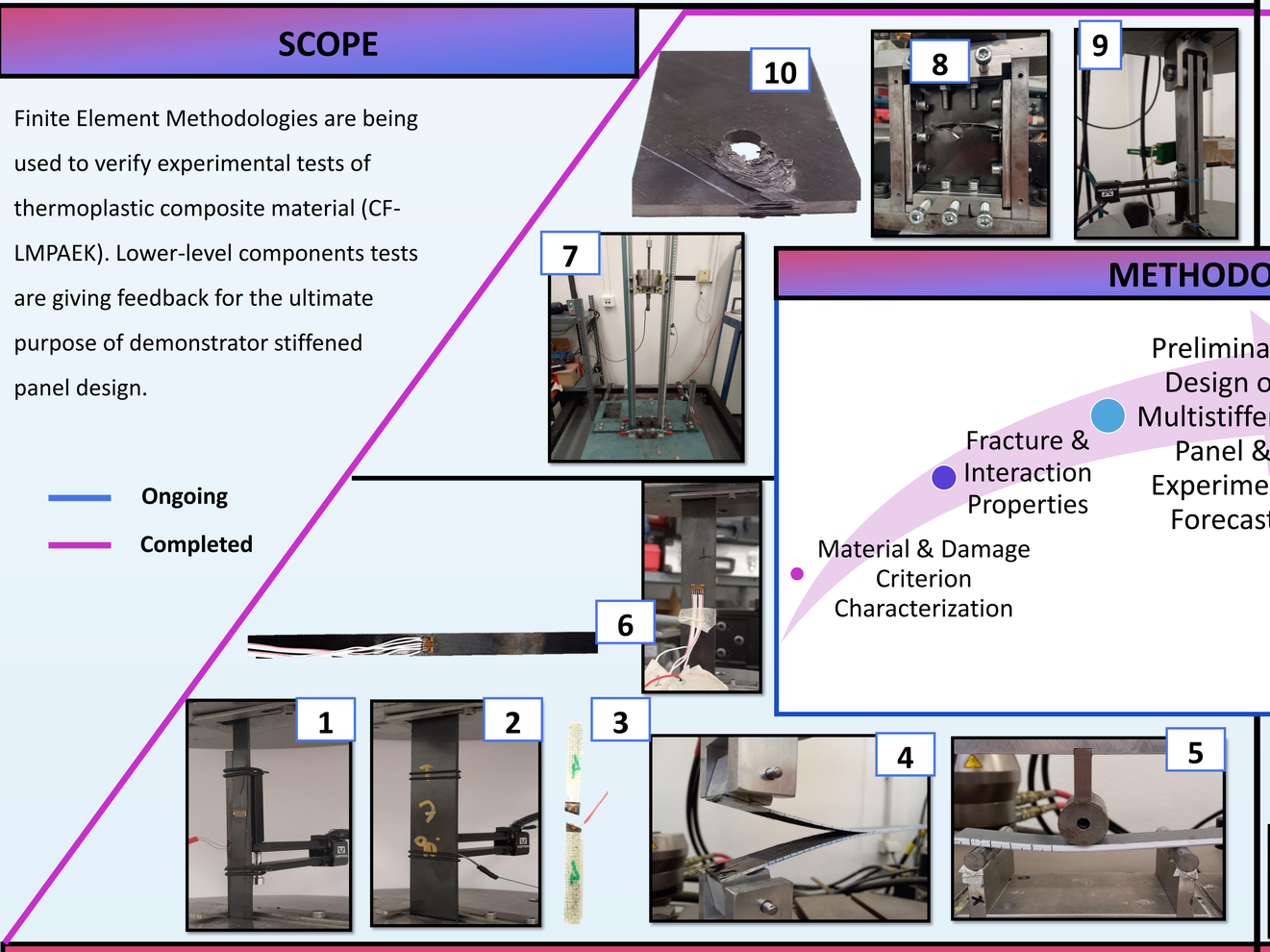






SCOPE

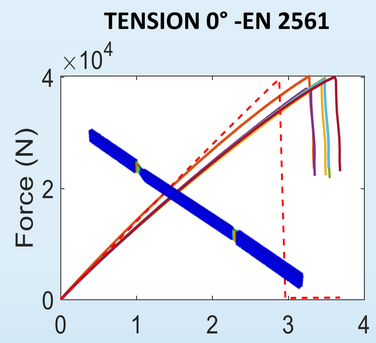
Finite Element Methodologies are being used to verify experimental tests of thermoplastic composite material (CF-LMPAEK). Lower-level components tests are giving feedback for the ultimate purpose of demonstrator stiffened panel design.

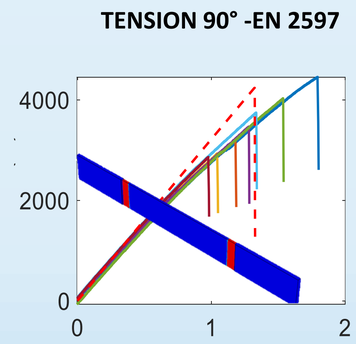


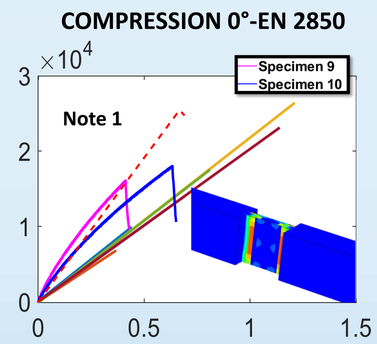
METHODOLOGY

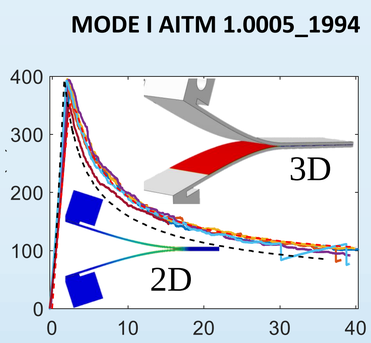
Figure: Pyramid of Tests of Thermoplastic Composite Material-Indicative Photos of Tests and Simulations

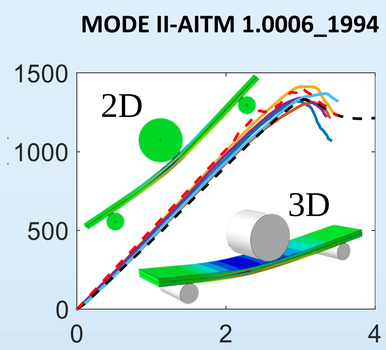
NUMERICAL MODELLING & DAMAGE VERIFICATION

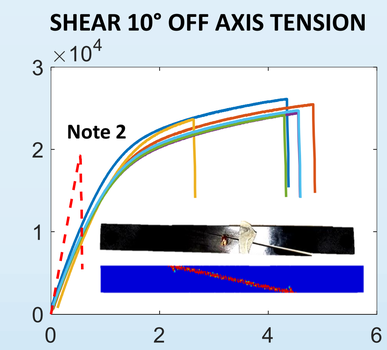


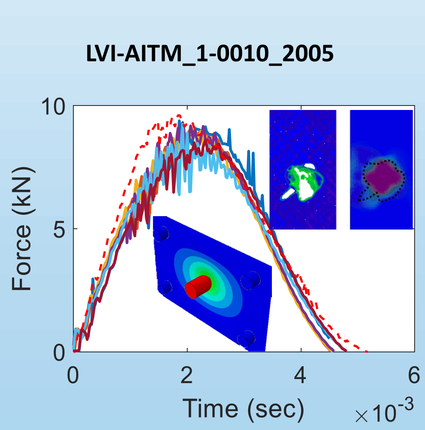


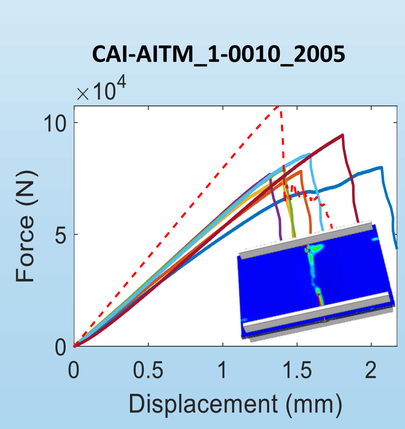


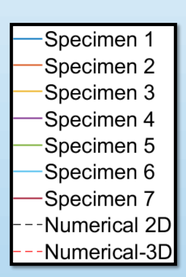












Note 1: Different slopes correspond to the investigation of tab usage. The tab is leading to preliminary deformation through bonding.

Note 2: Shear experiment +10° of axis seems to overpredict the young modulus E_{12} in comparison to ±45° shear experiment. Also, Hashin damage model fails to predict the plasticity of LMPAEK.

RESULTS & FUTURE WORK

1) Calibrated numerical models can forecast the experimental curves to a very good extend. Elastic, Fracture & Damage properties are obtained for further design. Though Hashin model in cases such as shear cannot reach the plasticity of LMPAEK matrix. A ***one parameter-plasticity damage model*** should be implemented in future.
2) There is a significant deviation between product and extracted properties mainly because of the different standard used. Specifically, the 10° off axis tension is expected to lead to higher elastic modulus against the $\pm 45°$ shear experiment.
3) The component level design and verification is ongoing. In this level the interface of skin/stiffener and frame will be tested into compression and under Mode I for the adhesive interface properties to be extracted. Then the demonstrator stiffened panel will be submitted to compression and internal pressure.

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