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Crashworthiness of a Tiltrotor Fuel tank bay

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1. INTRODUCTION

The fulfilment of the crash requirement is one of the main phase for the design of each new aircraft and this operation becomes even more demanding when the aircraft is a Tiltrotor. Indeed, such a kind of aircraft, being a hybrid between an airplane and a helicopter, inherits the requirements of both categories (CS-25 and CS-29). In particular, the fuel storage system must be designed in such a way that it is safe and does not generate fuel leakage even during a crash event. All that increases the survival chances of the crew and the passengers during catastrophic events, in fact the ignition of flames must be minimized as they drastically reduce the escaping time.

This work aims at the modelling and analysis of the drop event on the most critical wing section of the NextGen Civil Tiltrotor technology demonstrator NGCTR-TD (www.cleansky.eu/fast-rotorcraft-iadp), developed in the framework of Horizon 2020 Clean Sky 2 DEFENDER project. In particular, it is focused on the crashworthiness of the fuel storage system.

2. NUMERICAL APPROACH

Crash resistance requirements are considered from the earliest design stages and for this reason they are mainly addressed from a numerical point of view, by simulations that treat include single components and small/medium size assemblies. The high complexity level of the events to be simulated leads using very detailed models (which are able to identify any failure with consequent fuel leakage), and therefore, in order to decrease the computational costs, it is mandatory to adopt reduced sub-models. Then, any critical aspect is scaled and applied to the remaining parts of the aircraft (parts where the tanks are involved). The developed numerical models simulate all the main parts needed for a consistent structural behaviour of the investigated wing section under dynamic load conditions: the tank, the structural components of the wing, the fuel sub-systems (fuel lines, probes, etc.) and the fuel itself. During the crash event there are several parts that can come into contact with the tank structure and therefore, it is mandatory to evaluate which of these can be a damage source for the tank itself and thus may generate a fuel loss. Another important aspect is the fluid-structure interaction. In fact, under the action of strong acceleration fields, the fluid could stretch the tank structure and cause failures or contact with other parts that could compromise its integrity. The crash analysis was performed on the most critical wing section. As shown in the figure 1 the fullscale model includes the wing structure, the fuel systems allocated within it and the foam blocks that protect the tanks from the surrounding components.

The drop was simulated through an explicit analysis performed with the software Ls-dyna, by applying an acceleration pulse on the structure. The peak acceleration was derived from experimental data on similar items. Coupon test data were used to calibrate the fuel tank material model, the rubber flanges and the foam blocks. The evaluation of tanks/fuel system stress distribution and fluid behavior allows estimating any undesired failure upon a survivable crash event that could lead safety hazards for passengers and crew.

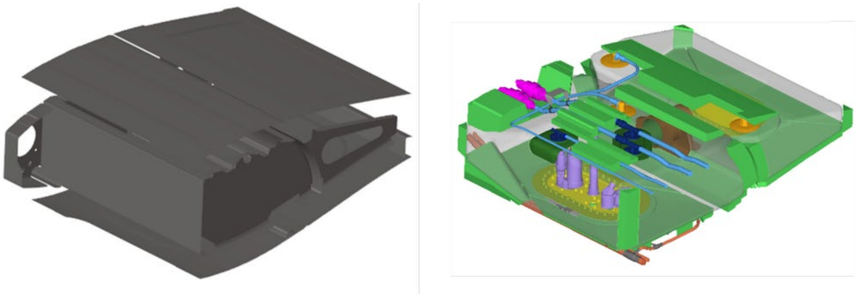

Figure 1 Wing structure and sub-system installed within it

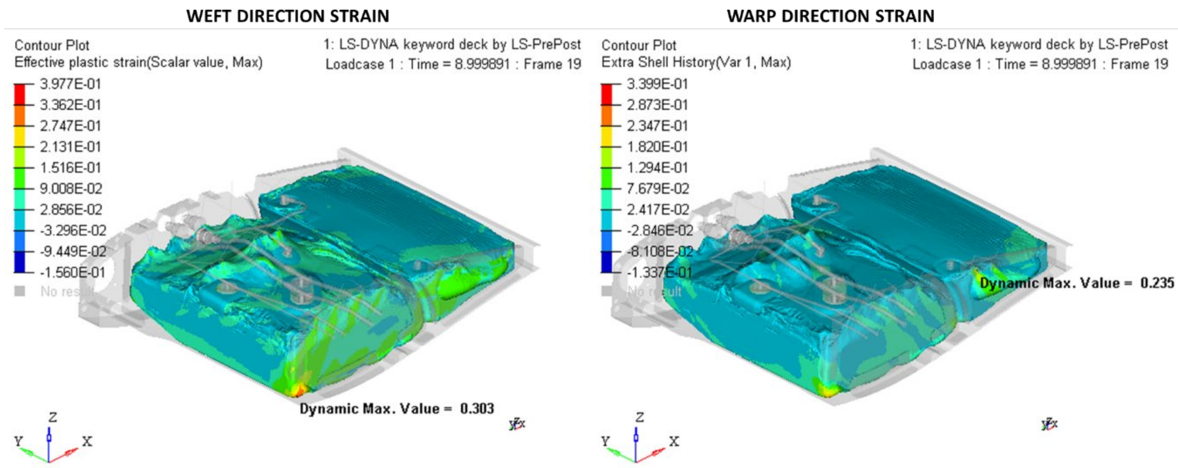

Figure 2 – Strain contours in weft and warp direction of the tanks structure

3. CONCLUSIONS

In this work the strain and stress distribution of the fuel storage system are evaluated in order to estimate any failure that may generate a fuel leakage. The results highlight that no failure is recorded on the components analyzed and the models set up so far will pave the way for future improvements with experimental drop data.

ACKNOWLEDGEMENTS

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