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Numerical evaluation of the damage scenario due to bird strike on the wing leading edge of a Tiltrotor

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1 INTRODUCTION

The bird strike is one of the most dangerous scenarios for the flight safety and, even if such events are rarely catastrophic, the bird strikes causes significant losses to the aviation industry. The FAA regulations requires that an airplane have to be designed to complete a flight after a collision with a medium size volatile (4-8 lb). These rules ensure that the aircraft design includes "bird-proof" qualification, especially with regards to the components with high impact risk like the windscreen/canopy, the engines and the wing and tail's leading edges, to have the permission for the flight. Bird strike requirement for a tiltrotor is an example of requirement tailored for the specific vehicle, since it is derived from CS-25 Airworthiness Requirements [1]. This work is focused on the modelling and analysis of the bird strike event on the wing's leading edge 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 T-WING project (https://www.cleansky.eu/clean-skys-t-wing-in-conversation-with-cira).

The wing leading edge hosts hydraulic and electrical routings, therefore to allow the installation and the maintenance of such parts, the leading edge's skin is a fully removable subcomponent. Moreover, just behind the leading edge, there are the composite front spar and the inter-connecting driveshaft. The contemporary failure of electrical cables and hydraulic pipeline is classified as a catastrophic failure as well as the damage of interconnecting drive shaft. Therefore, one of the most demanding design requirements, for the leading edge, is to prevent such failures. The achievement of safety standards together with the satisfaction of weight requirements involve a large number of tests on the structure with penalties on the development time and on the overall cost of the aircraft. Consequently, effective and accurate numerical simulation techniques have become mandatory to reduce both design time and costs.

2 METHODOLOGIES AND RESULTS

The present work aims to explore the possible weight reduction of the wing's leading edge according to the safety requirements, form a numerical point of view. The developed numeric models are able to simulate both the onset and the propagation of damages both on metallic components and on composite ones. The Smoothed-particle hydrodynamics (SPH) approach was adopted to modelled the projectile [2-4]. The residual strength of the primary structure of the wing as a consequence of the damage after bird strike has been evaluated by means of linear static analysis versus the get-home loads. In order to perform this step, a dedicated procedure has been developed to connect Abaqus explicit code to Nastran implicit code. In particular the post-impact damage status (Fig. 1) has been managed in order to overcome any problem related to differences in adopted computational grid.

A preliminary check on the safety of the systems routed in the leading edge has been assessed: the deformed shapes, due to the bird impacts, have been imported in the CAD model and the clash between the deformed shape and the systems have been highlighted (Fig. 2).

Several skin thicknesses were investigated under different impact loading conditions in order to select the one which minimizes the weight without compromising the safety. Each impact scenario is defined by two parameters: impact angle and impact station in span direction. The numerical results, and in particular the estimated damaged scenario, were used to define the minimum thickness compatible with the requirements at the minimum weight.

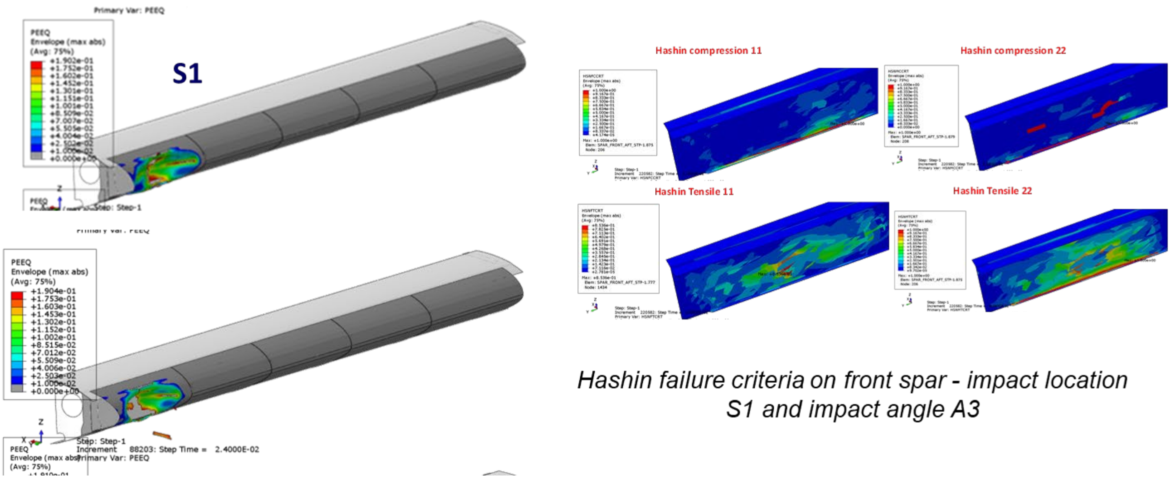

Fig. 1 Impact on 1st bay: Post-impact Deformed shape (left) and damage status on composite front spar (right)

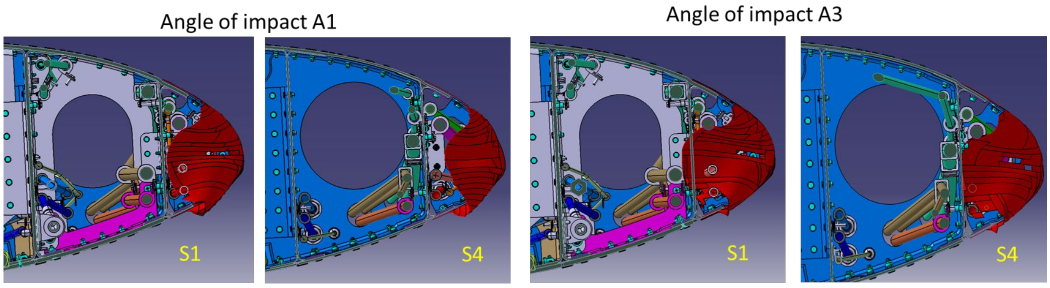

Fig. 2 deformed leading edge versus hydraulic and electrical routings

3 CONCLUDING REMARKS

In this paper the preliminary steps followed to achieve the minimum thickness for an aluminum leading edge of a tilt rotor have been presented. The results show that weight reduction is possible without compromising flight safety. The deformability of the leading edge allows to dissipate most of the impact energy and any its failure is also useful for this purpose. A further evaluation will be carried out by implementing the hydraulic and electrical pipelines in the FE models in order to predict with greater accuracy the possible damage that could be triggered by a bird impact.

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