Master Thesis: Nonlinearities of an aircraft Piccolo tube: experimental identification and finite element modelling by Pierre Trillet

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Nonlinear behaviour can be found in all physical systems, especially in aerospace structures. The aim of this master thesis consists in the improvement of an existing method for nonlinearity identification, the Acceleration Surface Method (ASM) and its application to the Piccolo tube, a widespread wings anti-icing system. The difference between the thermal expansion coefficient of the tube and the one of its support causes the apparition of clearances and thus impacts between these two devices. This method is based on the comparison between results coming from experimental measurements and those coming from numerical simulations performed on an updated nonlinear finite element model. The validation of the method is achieved by testing it on a full-scale F-16 aircraft whose wing-to-payload connections show nonlinear behaviour. Once validated, the method is applied to the first bending mode of the Piccolo tube highlighting the piecewise linear nature of both stiffness and damping nonlinearites. This latter also allows the accurate estimation of the parameters of both nonlinearities. The validation of the nonlinear finite element model is then carried out by comparing experimental measurements from qualification tests, imposed by the aeronautical norm DO160, namely the windmilling and the fan blade-off tests, with simulations results. This yields encouraging results showing that the numerical model is able to accurately represent the nonlinear dynamics of the first bending mode of the tube. This thesis shows that the improved version of the ASM could be used for nonlinear identification of many other industrial cases.