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Cessna Citation X Business Aircraft Stability Analysis Using Linear Fractional Representation LFRs Model

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Abstract : Clearance of flight control laws of a civil aircraft is a long and expensive process in the Aerospace industry. Thousands of flight combinations in terms of speeds, altitudes, gross weights, centers of gravity and angles of attack have to be investigated, and proved to be safe. Nonetheless, in this method, a worst flight condition can be easily missed, and its missing would lead to a critical situation. Definitively, it would be impossible to analyze a model because of the infinite number of cases contained within its flight envelope, that might require more time, and therefore more design cost. Therefore, in industry, the technique of the flight envelope mesh is commonly used. For each point of the flight envelope, the simulation of the associated model ensures the satisfaction or not of specifications. In order to perform fast, comprehensive and effective analysis, other varying parameters models were developed by incorporating variations, or uncertainties in the nominal models, known as Linear Fractional Representation LFR models; these LFR models were able to describe the aircraft dynamics by taking into account uncertainties over the flight envelope. In this paper, the LFRs models are developed using the speeds and altitudes as varying parameters; The LFR models were built using several flying conditions expressed in terms of speeds and altitudes. The use of such a method has gained a great interest by the aeronautical companies that have seen a promising future in the modeling, and particularly in the design and certification of control laws. In this research paper, we will focus on the Cessna Citation X open loop stability analysis. The data are provided by a Research Aircraft Flight Simulator of Level D, that corresponds to the highest level flight dynamics certification; this simulator was developed by CAE Inc. and its development was based on the requirements of research at the LARCASE laboratory. The acquisition of these data was used to develop a linear model of the airplane in its longitudinal and lateral motions, and was further used to create the LFR's models for 12 XCG /weights conditions, and thus the whole flight envelope using a friendly Graphical User Interface developed during this study. Then, the LFR's models are analyzed using Interval Analysis method based upon Lyapunov function, and also the 'stability and robustness analysis' toolbox. The results were presented under the form of graphs, thus they have offered good readability, and were easily exploitable. The weakness of this method stays in a relatively long calculation, equal to about four hours for the entire flight envelope.

Keywords : flight control clearance, LFR, stability analysis, robustness analysis
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