ERC Starting Grant
Executive Summary

The Nonlinear Tuned Vibration Absorber (NoVib)

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Even after more than one century of flight, both civil and military aircraft are still plagued by major vibration problems. A well-known example is the external-store induced flutter of the F-16 fighter aircraft. Such dynamical phenomena, commonly known as aeroelastic instabilities, result from the transfer of energy from the free stream to the structure and can lead to limit cycle oscillations, a phenomenon with no linear counterpart. Since nonlinear dynamical systems theory is not yet mature, the inherently nonlinear nature of these oscillations renders their mitigation a particularly difficult problem for both designers and engineers. The only practical solution to date is to limit aircraft flight envelope to regions where these instabilities are not expected to occur, as verified by intensive and expensive flight campaigns. This limitation results in a severe decrease in both aircraft efficiency and performance.

At the heart of this project is a fundamental change in paradigm: although nonlinearity is usually seen as an enemy, I propose to control - and even suppress - aeroelastic instability through the intentional use of nonlinearity. This approach has the potential to bring about a major change in aircraft design and will be achieved thanks to the development of the nonlinear tuned vibration absorber, a new, rigorous nonlinear counterpart of the linear tuned vibration absorber. This work represents a number of significant challenges, because (i) the novel functionalities brought by the intentional use of nonlinearity can be accompanied by adverse nonlinear dynamical effects and (ii) the project will venture well beyond nonlinear regimes that are just mere perturbations of linear dynamics. The successful mitigation of these unwanted nonlinear effects has received very little attention to date in the technical literature and will be a major objective of our proposed research; it will require achieving both theoretical and technical advances to make it possible. A specific effort will be made to demonstrate experimentally the theoretical findings of this research with extensive wind tunnel testing and practical implementation of the nonlinear tuned vibration absorber.

Finally, nonlinear instabilities such as limit cycle oscillations can be found in a number of non-aircraft applications including in bridges, automotive disc brakes and machine tools. The nonlinear tuned vibration absorber could also find uses in resolving problems in these applications, thus ensuring the generic character of the project.