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ABSTRACT: COMPARISON OF TIME-MARCHING AND DIRECT METHOD FOR LINEARISED RANS EQUATIONS IN AEROELASTICITY

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Aeroelasticity is one of the main concerns during the design of future jet engines. To address this issue, Computational Fluid Dynamics (CFD) is now routinely used. In the recent years, efforts have been done to build whole assembly model of fan flutter. These models are accurate enough to describe the flutter boundary of an engine fan, eventually taking into account acoustic wave reflections at the intake [1]. These models rely on Unsteady Reynolds-Averaged Navier-Stokes (URANS) computations which are associated to high restitution delays. In case of flutter, the unsteady flow is mainly linear and may be correctly modelled by linearised RANS (LRANS) equations. This reduces the computational costs and increases the range of parametric studies which could guide the engineering choices in the design procedure.

A first strategy to solve the 2D linearised potential equations using time-marching technique has been proposed by Ni and Sisto [2]. This method is commonly used to solve LRANS equations because of its simplicity and the low memory cost (see for example [3, 4]). However, such time-marching technique present high numerical instabilities which can be suppressed using a direct solver [5]. The direct method consists in writing the original linearised equations, which are elliptic, without adding a pseudo-time derivative. In this formulation, the unsteady complex unknowns only depend on the boundary conditions. Due to the large number of degrees of freedom, the arising linear problem is generally solved by an iterative algorithm. Chassaing et al. [6] present such a strategy using a Krylov subspace method.

In the present paper, time-marching and direct solver are compared. Both GMRES [7] and BiCGSTAB [8] Krylov subspace methods are implemented in the direct solver. The test case is an event of transonic stall flutter in a modern jet engine. The presence of shock-wave and the separation of the boundary-layer in the steady flow yields a stiff linear problem. The time-marching technique shows large numerical instabilities which sometimes lead to divergence. On the other-hand, the direct solver never fails to converge. The memory cost of the direct solver is three times larger than for time-marching. When the time-marching solver converges, the direct method shows a speedup of 20 on the restitution delays.

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