Multi-Disciplinary Analysis of Flow in Weapon Bays

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The numerical simulation of cavity flows is far from trivial. CFD studies have shown that Large Eddy Simulation (LES) and Detached Eddy Simulation (DES) results were in agreement with experimental data [1]. For faster computations than LES and DES, Scale Adaptative Simulation (SAS) [2] has been successfully validated for square cavities with and without doors [3]. The aeroelasticity of stores inside the weapon bay has only recently received attention [4], and store trajectory predictions need specialized computational tools. The most advanced published works [5,6,7,8] show that the variability of the store trajectories can be assessed with computational methods. However, the majority of the works with URANS models cannot accurately represent the cavity flow. LES or DES models are seen as more time consuming to perform stochastic studies related to the release of stores from within the cavity.

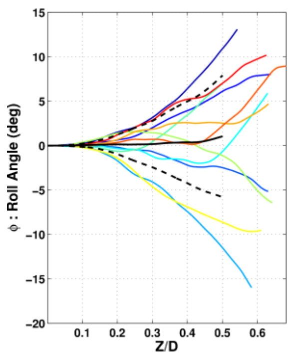

Figure 1: Roll angle for different store release.

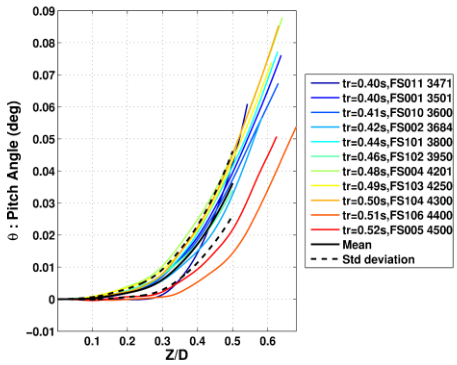

Figure 2: Pitch angle for different store release.

The CFD solver HMB3 can simulate store releases but also account for the aeroelastic deformations of the store. Store releases are carried out using a six degrees of freedom (6DoF) model and the overset chimera mesh technique. The SAS model is used so that it is possible to compute a large number of releases to make a stochastic study. Typically, a store is released at different times to estimate the variability of the trajectories [9].

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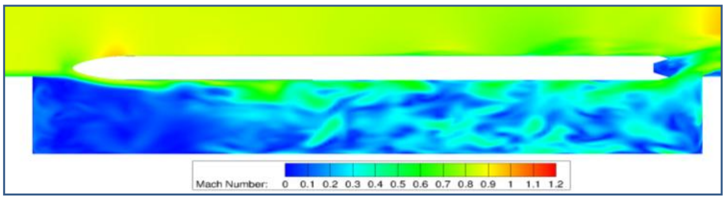

Figure 3: Flowfield during a store release computed with SAS.

To distinguish the behaviour between all the trajectory components, the force and moment signals are processed with the continuous Morlet wavelet transform [10]. This is a method for time frequency analysis used to determine which frequency bands dominate the structural loads. The components are grouped into categories. Trajectory components with a mean close to zero and large dispersion (Figure 1 and 4) are only driven by unsteady forces. Their scalograms show the larger amplitude for the frequency bands centered on cavity modes. The influence of the mean flow is negligible. Trajectory components with a mean far from zero and low dispersion (Figure 2 and 4) are driven by the mean flow, seen as the frequencies close to zero in the scalograms.

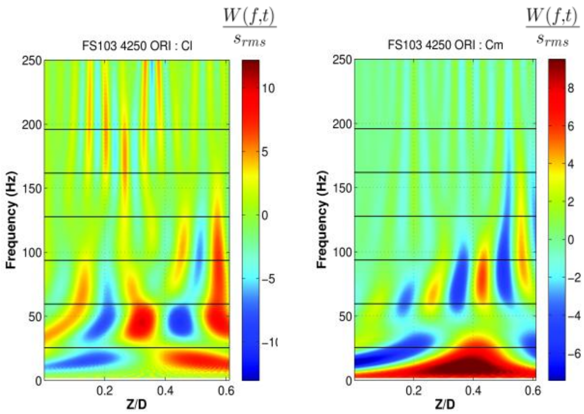

Figure 4: Scalogram of rolling moment Cl and of pitching moment Cm of a store release. Horizontal lines represent the Rossier modes [11] for a cavity length of 3.59m.

An aeroelastic module based on modal analysis is also available in HMB3. This method uses structural modes computed with NASTRAN and a mesh deformation module based on the inverse distance weighting interpolation. The complete store including the body and the fins can be simultaneously deformed. Furthermore, HMB3 can simulate store released including aeroelasticity. The complete paper presents the analysis of the trajectory variability with aeroelastic effects.

The financial support of MBDA Missile Systems is gratefully acknowledged. The use of the EPSRC funded ARCHIE-WeSt High Performance

Computer (EPSRC grant no. EP/K0005 86/1) is also gratefully acknowledged.

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