

## A COMPUTATION CHAIN IN FLUID-STRUCTURE INTERACTION FOR MARINE APPLICATIONS

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Fluid Structure Interaction (FSI) problems are commonly encountered in naval architecture. They can be solved with a monolithic or a partitioned approach [1]. The partitioned approach (or block-iterative method) consists in solving the fluid and the structure problems in a segregated way. Even if this can be done through a single solver, it is most commonly used in a co-simulation context and consequently it is especially well fitted to the resolution of complex FSI problems. Indeed, the co-simulation allows to use complex models for both the fluid and the structure without additional simplifications because each solvers can be numerically adapted to its problem.

In this work, two different general solvers are used. ISIS-CFD, which is a CFD solver available as a part of the FINE<sup>TM</sup>/Marine computing suite and dedicated to marine applications [2], is used to solve the fluid problem. To solve the structure problem, the solver MBDyn is used. It is an open-source solver intended for the simultaneous solution of multi-disciplinary problems including non-linear dynamics and aero-servo-elasticity among others [3]. The combination of this two solvers makes possible the study of a broad spectrum of applications in the marine field.

When a partitioned approach is used, convergence can be slow [4] and the coupling algorithm stability is not guaranteed due to the well known added mass effect [5] which is often met in marine applications. In order to reduce the computational time, the coupling iteration occurs during the non-linear iterations of the fluid solver because it is the most costly solver in our applications. To take into account the destabilising added-mass effect, a modification of the artificial added mass method is used. The original method consists in adding artificial added mass terms in the structure equations which do not affect the converged result. However this is not a suitable solution in a co-simulation context due

to the modification of the structure solver [6]. A relaxation technique of the structural kinematics is preferred because it can be directly handled by the coupling algorithm. Of course, the relaxation operator is related to the artificial added mass matrix. Stabilisation of the coupling algorithm is effective if the artificial added mass matrix is chosen high enough, but this work shows that also good convergence properties are obtained if the artificial added mass matrix is close to the physical one [7]. To compute an approximated or exact added mass matrix, an on-line resolution of an original pressure-like equation integrated in the fluid solver is performed [8].

The computation chain consisting of ISIS-CFD and MBDyn has been validated numerically for rigid bodies with six degrees of freedom and strong added mass effect. When it is possible, results were compared to experimental tests. Simulations of a ship in regular head waves are in good agreement with the experimental data. Harmonic analysis of pitch and heave motions are especially close to the experiments up to the second harmonic. Future works will be dedicated to simulate original physical configurations with complex mechanical systems and multi-body cases in the marine field.

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