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# Quantifying the Predictive Capability of OpenFOAM 5.0: Focused Wave Impacts with Floating Bodies

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**This work concerns the quantification of numerical accuracy for focused wave interactions with floating structures, using results obtained via a commonly used computational fluid dynamics (CFD) and linear wave superposition approach. It represents an individual contribution to the CCP-WSI Blind Test Series 3, where numerical predictions for a structure's motion are submitted for comparison with physical data, without prior access to this data. An estimation of accuracy based on the reproduction of physical empty tank data, and previous experience, is compared with the observed error in the structure's motion. The results imply that the error in peak values of heave and empty tank surface elevation are comparable, but the peak surge and pitch are substantially larger. This is likely due to a combination of numerical modelling errors, although numerical uncertainty must also be reduced in order to fully assess the problem.**

## INTRODUCTION

Two key issues that are limiting the routine use of computational fluid dynamics (CFD) are the uncertainty in its accuracy and the time required to obtain numerical results. The time taken to run a simulation is notoriously long, but this can be decreased through use of a larger computational resource. However, an often overlooked factor is the man-hours required to set up a case through processes such as mesh design; this has the potential to be considerably more time-consuming than the simulation time. For industry to benefit from the strengths of CFD models, the efficiency of the setup process needs to be increased, and this could be achieved through increased confidence in prediction by parametrically understanding numerical accuracy and providing standardised, "best-practice" implementations. An ever expanding use of CFD simulations for wave–structure interaction (WSI) applications (Windt, Davidson, and Ringwood, 2018; Palm et al., 2016; Devolder et al., 2018) has led to preliminary studies seeking to set the foundations for standardisation, such as the expansion of mesh convergence schemes to estimate uncertainty (Eskilsson et al., 2017; Wang et al., 2018), assessment of available wave generation methods (Windt et al., 2019a), the influence of mesh deformation scheme (Windt, Davidson, Akram, and Ringwood, 2018), and turbulence modelling under breaking waves (Brown et al., 2016). However, in general, there are very few established guidelines for design of WSI CFD simulations. Bearing in mind the enormous number of techniques and settings available to a user, it is therefore neither uncommon nor unexpected to see a wide range of solutions for a single problem where the desired solution is not known *a priori*, even when applying the same base CFD code (Ransley et al., 2019, 2020).

Ultimately, every numerical tool has limitations that must be well understood and minimised before standardisation can truly be achieved. Hence, this study aims to quantify and assess the predictability of the numerical accuracy of a commonly used methodology for assessing the interaction of focused wave events with a floating structure, building upon work conducted for a fixed structure (Brown et al., 2019). The scope of this work is to compare a blind estimation of numerical accuracy based on the reproduction of empty tank surface elevation and previous experience (Ransley et al., 2017), with the observed error in the structure's motion following the release of the physical data. The reported numerical results are obtained using open-source CFD software and expression-based wave generation based on linear superposition. The accuracy of the present model's motion predictions is assessed for two geometries and three focused waves of increasing wave steepness.

## CCP-WSI BLIND TEST SERIES 3 CASE STUDIES

The presented results represent an individual contribution to the CCP-WSI Blind Test Series 3 (Ransley et al., 2020), in which the submitted results are compared against both physical and alternative numerical solutions for varying wave steepnesses. CCP-WSI Blind Test Series 3 concerns the response of floating surface-piercing structures, representing simplified wave energy converters (WECs), to focused wave events of varying steepnesses. Two different structures are considered (Fig. 1): Geometry 1 is a

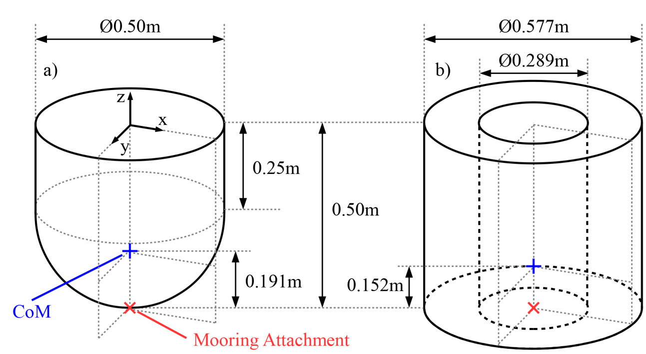


Fig. 1 The two geometries from CCP-WSI Blind Test Series 3: Geometry 1 (a) is a hemispherical-bottomed buoy; Geometry 2 (b) is a cylindrical structure with a moonpool.

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KEY WORDS: CCP-WSI Blind Test Series 3, uncertainty, WECs, error estimation, numerical modelling, extreme events.