

# Survey of Naval Computational Needs in Fluid-Structure Interaction

Dr. Paul Palo  
Naval Facilities Engineering Service Center  
Port Hueneme CA

Abstract. The objective of this paper appears deceptively straightforward: identify the computational needs of the U. S. Navy regarding fluid structure interaction (FSI). Ideally, the result would: (1) cover operations on the land, the sea surface, below the sea surface, and in the air, (2) evaluate all existing and emerging hardware classes and types in the U. S. Navy inventory, for (3) all conceivable operational scenarios that experience FSI. Lastly, the scope of the survey required a precise definition of the term “fluid structure interaction”.

To start with, the sheer size and incredible diversity of operations of the U. S. Navy makes satisfying all three criteria impossible. And FSI means different things to different people. *So - what choices were made for this subject survey?* Criteria (1) was taken as the primary objective - to insure that as many different types of operations were represented as possible. This had the secondary benefit of making this paper relevant (and hopefully interesting) to as wide an audience as possible at this conference. The fact that some FSI phenomena are universal (such as strumming of towed underwater cables) and therefore applicable to multiple Navy systems made incomplete coverage of distinct ship and aircraft classes and types [criteria (2)] acceptable. However, it was found that military operations are substantially more severe than civilian operations [criteria (3)], so this aspect is emphasized as critical, and in some cases unique, to Navy FSI challenges. The remaining issue was to define FSI, and that proved to be difficult. The classic definition of FSI is “elastic structural deformations of one body that modify the flow”, ideally involving self-excited/resonant instabilities. While this definition was emphasized wherever possible, restricting the allowable scenarios to this strict criterion proved to be too restrictive. The chosen strategy categorized examples as either strong (classic definition) or weak (e.g., interaction, perhaps at different time scales, or not elastic), then either quasi-periodic (i.e., strumming) or transient (ship slamming).

Summarizing, this survey qualitatively focuses on a representative set of real-world Navy systems and FSI scenarios. Examples are given for land, sea, and air, with underwater systems receiving the greatest emphasis. In each instance, specific conditions critical to that operation are clearly identified, and if applicable, contrasted to state-of-the-art modeling capabilities or data sets. How the Navy dealt with each problem is also discussed.

Example systems to be presented include:

underwater cables	laying, suspended, towed (ship and helicopter)
underwater propulsion	biomimetrics, propeller singing
seakeeping	vessel slamming in extreme seas
acoustics	conformal arrays
aircraft	wing and rudder flutter, buffeting, turbine blade fatigue
land	steam boilers
Miscellaneous	two-body interaction, vessel-pier interaction