# Underwater flow noise from turbulent boundary layers over inhomogeneous surfaces

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Noise induced by turbulent flows is of importance in underwater acoustics, since it can contribute to the source level of a moving vehicle, such as a ship, or it can act as interference noise for hydroacoustic antennas. In case a hydroacoustic antenna is towed behind or attached to a platform that moves at sufficient speed, a turbulent boundary layer forms at the outside of the antenna hull. Wall pressure fluctuations beneath the boundary layer flow excite the elastic hull structure and induce noise in the quiescent interior of the antenna, which is often filled with water or oil. This hydroacoustic noise can contribute significantly to the so-called sonar self-noise and limits the performance of a sonar system at larger speeds [1].

In order to study the basic physical mechanisms of flow noise generation in hydroacoustic sensor systems and understand their relevance in the context of the environmental and acoustic conditions at sea, a towed body measurement system for flow noise experiments under sea conditions has been built by ATLAS Elektronik in collaboration with WTD 71 [2]. A schematic drawing of the FLAME (Flow Noise Analysis and Measurement Equipment) towed body is depicted in figure 1 (a). Different flat plate configurations can be laterally attached to the towed body and turbulent wall pressure fluctuations as well as hydroacoustic noise on the reverse side of plate in the interior of the towed body can be measured simultaneously. Several towing experiments on underwater flow noise have been performed with the research vessel ELISABETH MANN BORGESE (Leibniz Institute for Baltic Sea Research, Germany) and the FLAME towed body in Sognefjord, Norway, in recent years [3].

Surface inhomogeneities can significantly alter the behavior of a turbulent boundary layer flow. An example arises, for instance, from a local cross-sectional enlargement of a towed array which can lead to separation (and reattachment) of the axisymmetric turbulent boundary layer [4]. Such inhomogeneities typically have substantial influence on the generation of flow induced noise in hydroacoustic antennas.

In this work we have studied the generation of interior noise induced from turbulent boundary layer flows over flat plates with different types of surfaces inhomogeneities, i.e. surface roughness, a spanwise step, and a wavy pattern. As an example, a schematic view of the step configuration as well as the coherence of turbulent wall pressure fluctuations beneath the boundary layer flow behind the step is shown in figure 1 (b) and (c), respectively. The influence of surface inhomogeneities on turbulent wall pressure fluctuation and interior noise was determined in all three cases by comparison to a respective flat plate configuration having the same material parameters. The experiments were performed with the FLAME towed body under sea conditions. The work is aimed to contribute to a better understanding of the role of surface inhomogeneities for the increase, but also for the reduction of flow induced noise in the interior of hydroacoustic sensor systems.

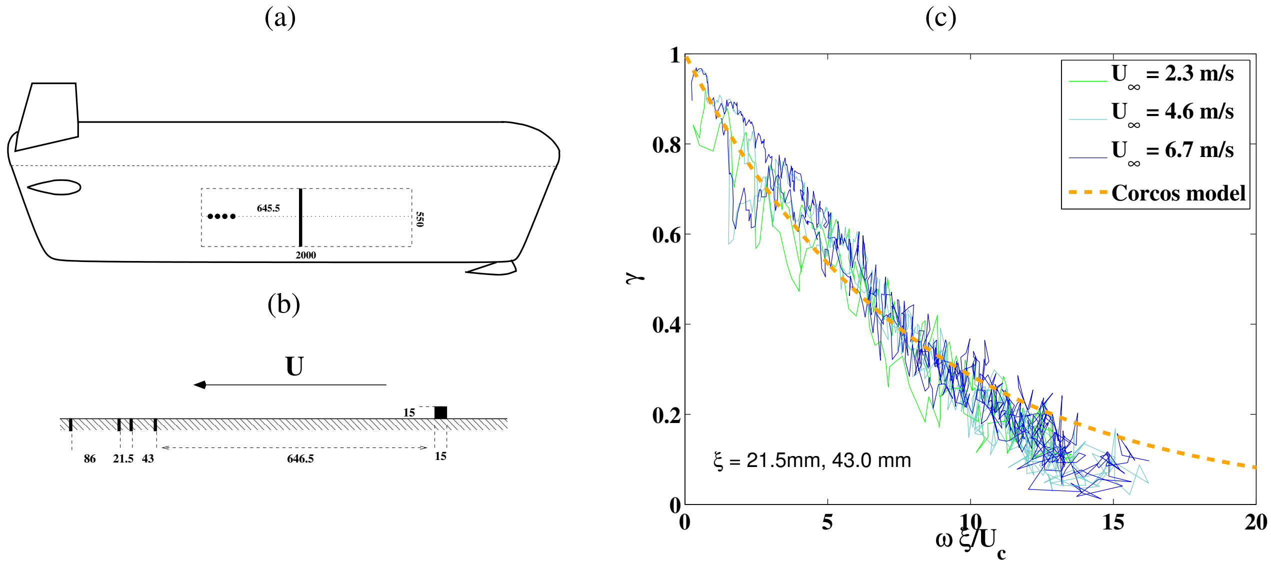


Figure 1: (a) Schematic view of FLAME towed body with flat plate area and local spanwise step, (b) schematic side view of flow geometry with step and (non-equidistant) positions of flush-mounted hydrophones, and (c) streamwise coherence functions $\gamma(\omega\xi/U_c)$ for different hydrophone distances $\xi$ and towing speeds $U_\infty$. A departure from the Corcos model with $\alpha$ = 1.25 can be seen.

## References


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