

## Hydrodynamic Forces on ROVs near the Air-Sea Interface

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### ABSTRACT

The control and operability of remotely operated vehicles (ROVs) are strongly influenced by their hydrodynamic characteristics especially in the near-surface wave-affected zone. This project has considered a 1/4-scale model of a Super Scorpio, representative of current bluff-body workboat ROVs, together with simpler geometrical configurations, to determine the hydrodynamic coefficients in this region and the generality of these results to other vehicles. Proximity to the air/sea interface increases the inertia and drag coefficients, compared to the standard values based on conditions of deep submergence. In addition, for steep waves, the present research proposes the use of two values of inertia coefficient per wave cycle. This may be contrasted against the more usual practice based on one (averaged) value which leads to an underestimation of the peak hydrodynamic forces.

### INTRODUCTION

Accurate hydrodynamic coefficients are important both for control algorithms and for determining the wave loading and motion response of ROVs. The standard practice usually assumes constant deep-submergence values based on published data for simple geometrical shapes such as prisms and cylinders (e.g., Barltrop and Adams, 1991). Sometimes, however, measured experimental values are used for specific vehicles (Nomoto and Hattori, 1986; Sayer and Miller, 1991). The present project has compared the behavior of these coefficients for an intervention-type workboat ROV against a solid box and against published results for other vehicles. It is difficult, and perhaps of dubious practical value, to attempt to simulate numerically the flow around and through such a modular vehicle, carrying a wide range of equipment having equally diverse geometrical shapes. The ROV chosen for the present study is the Super Scorpio. (The 1/4-scale model used for the present study is shown in Fig. 1). This has a space-frame configuration, of a type that is in wide use throughout the offshore industry. Thus it is possible to consider both the generality of the Super Scorpio results as well as the trends, differences and scope for interpolation/extrapolation between the ROV results and data for simple solid shapes. Tests on the latter also enabled us to validate our experimental procedure.

A further outstanding question concerns the variation of the drag and inertia coefficients,  $C_D$  and  $C_M$ , when the vehicle is close to the air/sea interface. As the vehicle enters the water during launching, the wave-induced heave responses are critical in determining the likelihood of tether snatching, often caused by wave slamming on the vehicle or its launching frame, and the magnitude of the resultant large dynamic loading on both tether and vehicle. If the ROV is launched over the side (or stern) of a ship, the probability of snatching is increased as the heave and roll (or pitch) of the mother vessel augment the vertical motions of the ROV when the vehicle is entirely in the air, but may be out of phase when the vehicle is partially or fully submerged in waves.



Fig. 1 1/4-scale model of Super Scorpio ROV

Interest in these loads is not confined, however, to the launch and recovery phases of ROV operations: For example, the vehicle may be required to undertake inspection or repair activities on a jacket structure at depths where the effects of the wave loading are clearly felt. The complexity of this problem is compounded by the variation in the hydrodynamic characteristics of the ROV with the depth of submergence, and by nonlinearities inherent in the wave kinematics.

Once the vehicle is immersed, other modes of motion also become important, in particular the horizontal planar motions of surge, sway, and yaw, which affect the ease of positioning and maneuvering the vehicle either for intervention or for docking in the wave-affected zone.

### APPROACH

The hydrodynamic loading on ROVs is generally predicted using coefficients obtained from tests which simulate both steady and oscillatory flows, usually carried out in conditions representing deep submergence. (A variety of facilities are available, including planar motion mechanisms, flumes and wind tunnels).

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