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# Time-Domain Analysis for Floating Bodies in Mild-Slope Waves of Large Amplitude

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In Lin & Yue (1990), a large-amplitude motion program (LAMP) was developed to study three-dimensional time-domain motions and loads of floating bodies in waves. In that so-called "body-exact" approach, the body boundary condition is satisfied exactly on the instantaneous surface of the moving body under the mean free surface while the free-surface boundary conditions are linearized. The problem is solved by using a transient free-surface Green function sigularity distribution method. The motions of the body are either specified or obtained by solving the equations of motion at each time step. The validity and practical utility of LAMP have been demonstrated by several studies including predictions of large-amplitude motion coefficients, motion history of a ship advancing in an irregular seaway, as well as bow flare effects on ship dynamic loads (see Lin & Yue 1990, 1992; Lin et. al. 1991, 1992).

A recent application of LAMP for the prediction of motions and loads of a cruiser hull, the CG47, in large-amplitude waves indicated that the LAMP results were not satisfactory in this case (Lin & Meinhold 1991). A detail study revealed that the geometry misrepresentation was the main cause of the inaccurate predictions. The approximation used in LAMP can be justified in principle upon the assumptions of small incident wave amplitudes and slenderness of the body geometry in the directions of the large-amplitude motions. The original intent was to represent the body geometry closer to the physical situation. However, for the CG47 cruiser in large-amplitude waves, the original good intent for more accurate hydrodynamic calculations in LAMP made the matter worse. As can be seen in Figure 1, the geometry of CG47 used in the LAMP calculation at one time instance is represented by the line shaded area under the *mean* free surface (dash line). The geometry features near the transom stern are totally lost in the LAMP representation. This caused several problems : (1) hydrostatic and Froude-Krylov wave forces in the stern area were not included; (2) true hydrodynamic effects for the portion of the ship under the wave surface were not accurately accounted for; and (3) small deadrise angle panels in the stern area caused numerical problems.

In this work, we describe a practical remedy for computing ship motions and loads in large-amplitude waves which have relatively mild slopes. Instead of satisfying the body boundary condition on that portion of the hull which is below the *mean* free surface as in LAMP, in this approach, the body boundary condition is satisfied on the instantaneous wetted hull under the *incident* wave profile. At each time step, local free surface elevations are used to transform the body geometry into a computation domain with a deformed body and a flat free surface. By linearizing the free surface boundary conditions about this incident wave surface, the problem is solved in the computation domain using a linearized free-surface transient Green function. As an illustration, the dot shaded area in Figure 1 shows the portion of the instantaneous hull boundary considered in this approach. This formulation has been consistently derived based on the assumption that the slopes of the incoming waves is mild and the scattered waves are small compared to the incident waves. In this new approach, the correct hydrostatic and Froude-Krylov wave forces are also readily included. Preliminary tests indicate that this large-amplitude mild-slope approach dramatically improves the prediction of motions and loads for vessels such as the CG47 cruiser in large-amplitude waves.

The validity of the current approach, details of the theoretical formulation and numerical algorithm of the large-amplitude mild-slope approach will be discussed at the Workshop. Numerical results for several ship hulls using this new approach will also be presented.

## REFERENCES


Lin, W.M. & Yue, D.K.P. (1990), "Numerical Solutions for Large-Amplitude Ship Motions in the Time-Domain", *Proc. 18th Symp. Naval Hydro.*, U. Michigan, Ann Arbor, MI, U.S.A.

Lin, W.M. & Meinhold, M. (1991), "Summary Technical Report of Hydrodynamics Loads Calculations for Advanced Marine Enterprises," SAIC Report No. 91-1050 (revised).

Lin, W.M. & Yue, D.K.P. (1992), "Wave Forces on A Surface-Piercing Sphere Undergoing Large-Amplitude Motions," Seventh International Workshop on Water Waves and Floating Bodies, Val de Reuil, France.

Lin, W.M., Meinhold, M. & Salvesen, N. (1992), "IDEAS System for Ship Motions and Wave Loads," SAIC Report No. 92-1187.


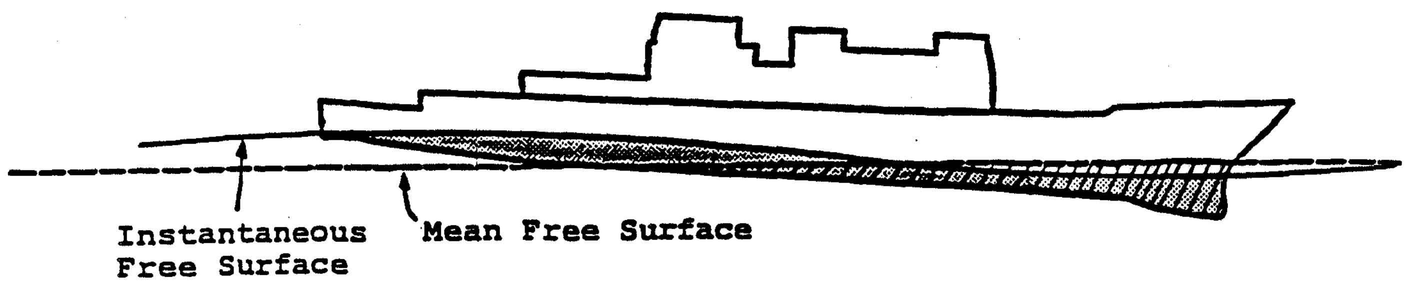


Figure 1 Instantaneous Geometry of the CG47 Cruiser at One Time Instance in Waves