# Numerical Modeling of Passing Vessel Impacts on Berthed Vessels and Shoreline

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The continual introduction of larger and faster deep-draft vessels in narrow waterways during the last two decades has created new environmental impacts in coastal zones, ports and inland waterways. Surges generated by passing vessels can significantly contribute to shoreline erosion, causing extensive re-suspension of sediments in the surf zone, and provide significant hydrodynamics loads on berthed vessels and shoreline structures. In the present paper, the development and application of the Vessel Hydrodynamics Longwave Unsteady (VH-LU) model is presented. VH-LU was developed though cooperation between the Ukrainian Center of Environmental &Water Projects (UCEWP) and Coast & Harbor Engineering (CHE) under a grant from the U.S. Civil Research & Development Foundation.

In the past few years, the numerical simulation of vessel-generated waves in harbors with complex geometry on the basis of linearized shallow water equations has been demonstrated (Fenical *et al* 2002). Implementation of HIVEL2D and ADH numerical finite element codes based on full shallow water equations for vessel surge modeling has been presented recently by Berger and Lee (2005). Numerical model of vessels hydrodynamics in shallow water for the engineering applications has been developed recently the basis of Boussinesq equations by Nwogu (2003).

The new VH-LU model is based on the finite-volume approach for solving the Nonlinear Shallow Water Equation (NSWE). Its numerical engine is an extension of the COASTOX modeling system (Kivva and Zheleznyak 2002) developed to simulate shallow water hydrodynamics, including 2-D wave propagation and run-up in coastal areas. The VH-LU model uses the approach developed in the COASTOX system for the “through-on” simulation of the runup zone that does not require introduction of special mechanisms for description wave front movement on the beach. The VH-LU model describes vessel long-wave generation as a source term in the NSWE depending from the vessel hull displacement. Vessel hulls are input into the model as two-dimensional finite difference grids. Vessel hull shapes developed and tested to date include general cargo-type, containership, tanker, barges and analytical shapes. The displacement of water in the model over time is calculated from user-specified variable sailing lines within the domain and vessel accelerations and speeds.

Since it was developed as an extension of the COASTOX system, a sediment transport and bottom morphology module based on the suspended sediment advection-diffusion equation is used in VH-LU to simulate sediment transport in nearshore and swash zone. The VH-LU model simulates vessel longwave hydrodynamics while taking into account tide-generated, wind-generated and wave-driven currents as initial or boundary conditions in areas of complicated geometry, including the areas of the longwave runup at the shoreline. The hydrodynamic loads from passing vessel long-waves on berthed vessels or coastal structures are calculated using the Vessel Hydrodynamics Longwave Load (VH-LL) module of the modeling system. The VH-LL module uses data from the VH-LU model including dynamics of water velocities and water surface elevations.

The VH-LU model has been verified using measured field water surface elevation data from the Port of Oakland Inner Harbor Waterway (Shepsis *et al* 2001). Figure 1 shows a comparison between measured and predicted drawdown (vessel-generated surge) for two passing vessels. The VH-LU model has been applied on numerous coastal engineering projects for evaluation of vessel-induced erosion and shoreline impacts. Figure 2 shows the predicted water surface elevation fluctuations for the vessel "TMM TABASCO" moving at 9.6 knots in the Mississippi River Gulf Outlet (MRGO). The model was also verified with field data measured in the MRGO for the passing vessel event (Nwogu 2003).

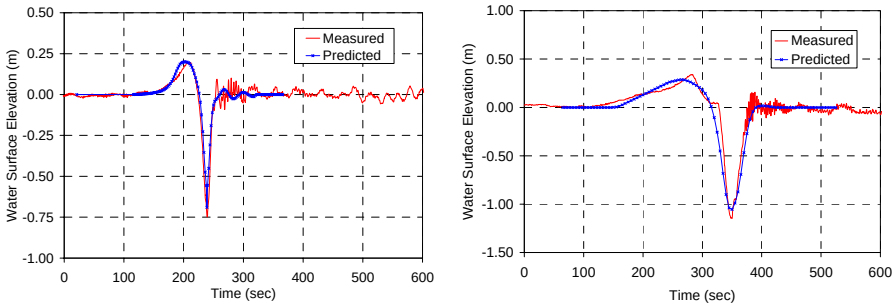


Figure 1. Measured and computed (VH-LU) water surface elevations for passing vessel events at the Port of Oakland Inner Harbor Waterway, May 1999. At left is the "FANAL TRADER" at 13.7 knots, at right is the "EL DORADO" at 8.6 knots.

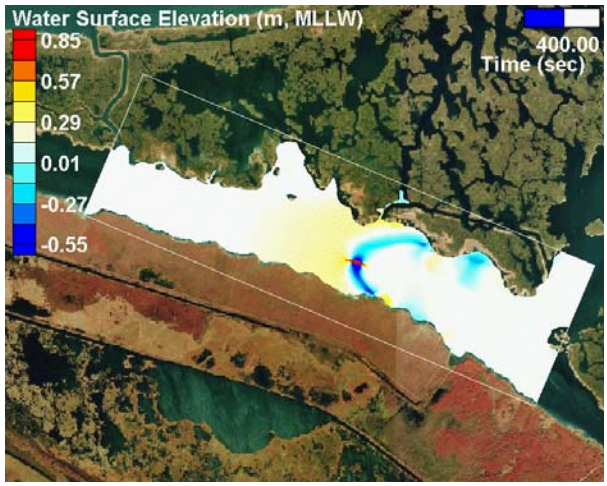


Figure 2. VH-LU computed water surface elevations for passing vessel "TMM TABASCO" in the MRGO.

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