

# GridgenApp

A Unique Gridgen® Application



## Hybrid Meshes for Wave Capturing of Surface Ship Flows

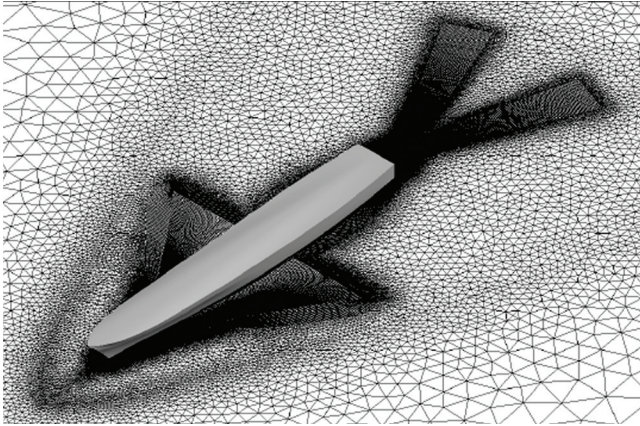


Figure 1. Mesh of the water-air surface.

Modeling of free surface flows for hydrodynamic applications can be accomplished using surface fitting methods for low to medium Froude numbers. But when the Froude number is larger, such as flows associated with steep and overturning waves, the fitting methods encounter difficulties. The University of Tennessee SimCenter at Chattanooga has implemented a multiphase surface capturing approach to handle these higher Froude number cases,  $Fr > 0.4$ . This approach has been applied to several validation cases, including the R/V Athena research vessel shown in this article. The R/V Athena is a converted high speed U.S. Navy patrol gunboat capable of speeds of at least 35 knots with a length of  $L=154$  feet. Simulations were performed at model scale and compared with measurements taken at the Naval Surface Warfare Center, Carderock Division using a  $1/8.25$  scale barehull model of the R/V Athena.

The meshing requirements of these mixed phase analyses are very demanding. Since the interface between the water and air is being captured, the grid must be highly resolved in the zone where the water-air surface is expected, especially in the direction normal to the free surface. The density ratio across the interface is on the order of 1000 to 1. This translates into a typical vertical spacing requirements on the order of  $1.0e^{-3}$ . When the surface is highly irregular, such as an overturning wave, this mesh spacing is required in all three directions. A fully unstructured mesh would

require an exorbitant number of tetrahedral elements to fully resolve all regions of the domain where the high gradients are expected. Structured meshes can be used to efficiently resolve the air-water interface in calm regions of the domain, but would result in over-resolving far field regions due to propagation of the grid resolution near the air-water interface. Therefore, a hybrid mesh topology was chosen to model the complete domain consisting of the surface ship, the air-water interface and far field.

Gridgen was used as the primary tool to create the viscous meshes for these analyses. Structured blocks were created to resolve the air-water interface near the bow and transom stern regions of the ship where steep and overturning waves were anticipated. In the vertical direction, these blocks extend  $z/L=0.025$  above and  $z/L=0.0125$  below the calm water surface. Figure 1 shows the mesh at the calm water line. The calmer regions of the air-water interface were modeled with prismatic elements. These elements were created by marching a triangulated mesh in the vertical direction. The vertical spacing matched the spacing defined in the fully structured blocks just mentioned. The remaining regions of the domain were modeled with fully unstructured tetrahedral elements. In addition, viscous elements were inserted normal to the ship surface using an in-house developed viscous mesh generation program.

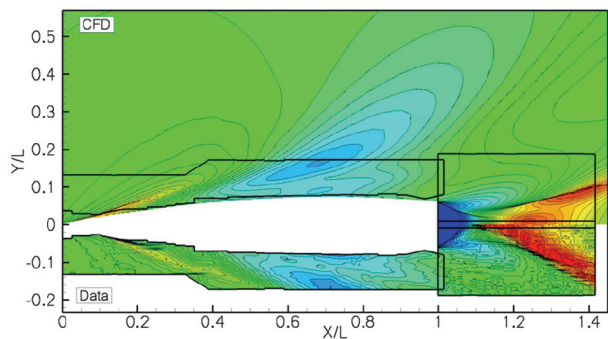


Figure 2. Comparison of predicted and measured free surface wave.

Courtesy of Steve Karman and Robert Wilson, UT SimCenter at Chattanooga, University of Tennessee at Chattanooga. Reprinted from an article from the Spring Focal Point 2006.