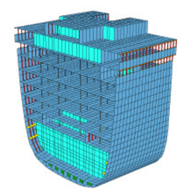
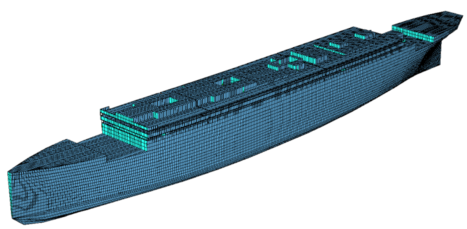
MAESTRO CORE CAPABILITIES

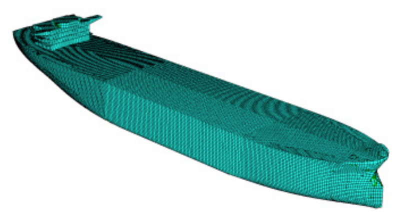
MAESTRO is a design, analysis, and evaluation tool specifically tailored for floating structures and has been fielded as a commercial product for nearly 30 years with a world-wide user base. MAESTRO's history is rooted in rationally-based structural design, which is defined as a design directly and entirely based on structural theory and computer-based methods of structural analysis (e.g., finite element analysis and structural limit state evaluation). At MAESTRO's core is a structural design tool developed to suit the needs of ship designers and naval architects. Further, the MAESTRO development staff and support team are themselves naval architects who understand the ship design and analysis process.

Modeling





MAESTRO's modeling paradigm is organized to rapidly generate a finite element model of an entire ship. Using high-level building blocks (i.e., MAESTRO *substructures* and *modules*), MAESTRO can leverage longitudinal uniformity typically found within portions of a ship (e.g., plating thickness or frame size throughout a cargo hold, etc.). Each module has its own local coordinate system, and can be copied, rotated or transformed. This paradigm not only supports the rapid *creation* of the finite element model but also the *modification* of the finite element model, which is routinely required during the design process. Hull girder properties such as inertias, cross-sectional area, neutral axis, and section modulus can be plotted and queried for any section cut within the model.



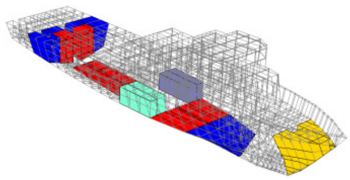
In addition to its built-in modeling capabilities, MAESTRO can read geometry from FEMAP, Nastran, NAPA Steel, DXF, and polygon mesh (.ply) files. Once a model is loaded into MAESTRO from another source, *all of the hull girder properties, ship-based loading, post-processing, and advanced capabilities are available to the user just as if the model had been created in MAESTRO.*

MAESTRO also provides fine meshing capabilities which allow the global model to be automatically refined while maintaining the original scantling properties and loads. The fine mesh model(s) can be analyzed as a separate model or integrated into the global model. Either option automatically applies the appropriate boundary conditions to impose the global loads onto the fine mesh model(s).

Loading

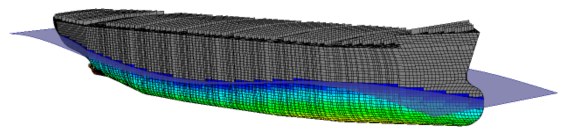
MAESTRO offers numerous ship-based loading patterns (e.g., Basic Loads: Cargo Loads, Liquid Tank Loads; Sea Environment: Hull Girder Loads/Sea Loads/Ship Motion Loads; and Operational Loads: Slamming/Flooding/Docking) to accurately and efficiently produce the necessary load cases. These load patterns include scaled masses, panel pressures, mass distributions, tank loads, longitudinal and transverse hull girder load distributions, hydrostatic loads (stillwater/wave), additional accelerations, and hydrodynamic loads.

Tanks are easily modeled and loaded in MAESTRO similar to hydrostatic analysis tools by leveraging the existing structural model to define the tank boundaries. Loads can be specified by a discrete mass or percent filled. MAESTRO creates the appropriate loads based on the user-defined density



and permeability and automatically manages the element pressure side, even for elements shared between tank boundaries. Tank loads can be varied between load cases allowing the user to create multiple conditions within a single model. For each load case, a tank table is available summarizing the tank volumes, loads, and centers of gravity.

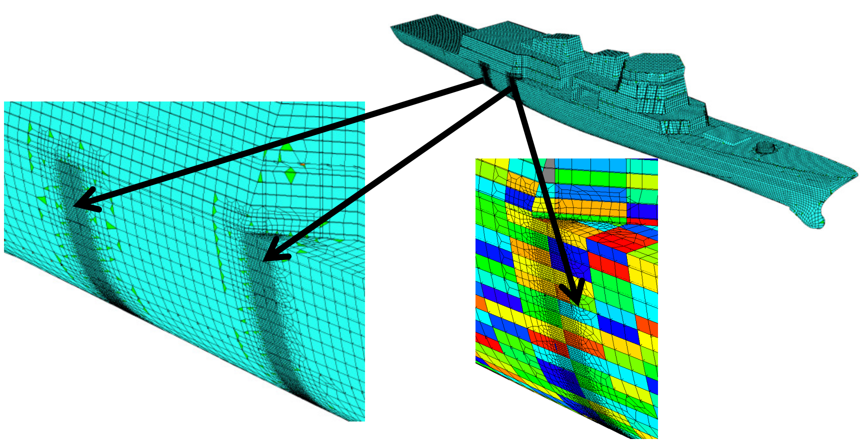
MAESTRO also includes a load balance capability which automatically balances the model in a stillwater or wave condition for each load case. Once a model is loaded and balanced, multiple longitudinal and transverse distributions (e.g., weight, buoyancy, shear force, bending moment, etc.) are available to quickly QA the model before solving.



Structural Evaluation

In addition to calculating displacements and stresses using the finite element analysis method, MAESTRO also performs an automatic failure evaluation of the principal structural members. Core to the modeling paradigm in MAESTRO is the ability to retain critical stiffened panel boundary conditions and parameters (e.g., true panel spans) for proper and accurate buckling assessment downstream in the analysis process. This automatic stiffened panel search capability can be performed on a MAESTRO model, imported fine mesh model, or combination of coarse mesh and embedded fine mesh. The principal structural members of the global model typically include all of the stiffened panels and their associated beams, transverse frame segments and longitudinal girders. These failure evaluation modes address yielding, buckling, and other major failure modes typically found in design criteria.

For each load case that is being analyzed, the failure analysis provides a quantified evaluation of the failure modes for each principal structural member. This is one of the most powerful failure evaluation capabilities available to the ship structural engineer, and results in a comprehensive level of information that identifies structural problems associated with events such as buckling. These structural failure evaluations are used by the structural engineer to assess the adequacy or degree of conservatism that is represented by the design. The available structural evaluation methodologies include MAESTRO Evaluation, ALPS/ULSAP, ALPS/HULL (hull girder ultimate strength), ABS High Speed Naval Craft (HSNC) and Offshore Buckling Guide, and US Navy NVR criteria.

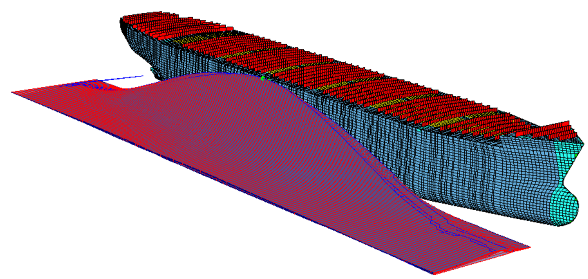


A structural evaluation framework in MAESTRO exists so that additional design criteria and class rule checks can be easily implemented as needed. The stiffened panel parameter and load generation capability is modularized so that it can be leveraged with multiple rule sets.

MAESTRO ADVANCED CAPABILITIES

MAESTRO-Wave (Integrated Hydrodynamic Loads Prediction)

The MAESTRO-Wave module provides the ship designer with an integrated frequency-domain/time-domain computational tool to predict the motions and wave loads of floating structures. Because this tool is integrated into the MAESTRO interface, the learning curve is greatly reduced and the need to transfer data between programs is eliminated. MAESTRO-Wave takes advantage of the existing structural mesh and defined loads to formulate the equations of motion. This approach results in a perfect equilibrium for the structural model so no inertia relief or artificial loads are required to balance the model. Bending moments, shear forces and torsional moments are all automatically in closure. MAESTRO-Wave can also account for tank sloshing loads and provides several roll damping options. The computation of hydrodynamic forces is based on one of several user-selected analysis methods:

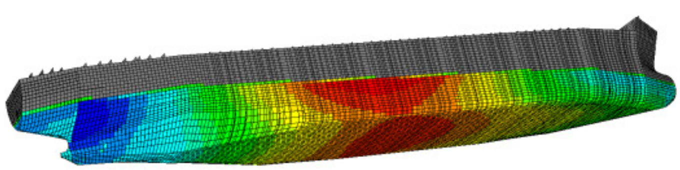


- 3D panel potential theory using the zero speed Green function with a speed correction parameter
- 2D Strip Theory using either the Free Surface Green Function or the Rankine Source Method
- 2.5D High Speed Strip Theory using the Rankine Source Method including the forward speed term

Regardless of the method used, the MAESTRO-Wave output provides a unit wave database and panel pressure loads for all of the speeds, headings, and wave frequencies run. A variety of visualizations and output data are available to aid the user with post-processing.

Extreme Load Analysis (ELA)

The ELA module allows the user to calculate hull girder load response RAOs, and provides the necessary short-term and long-term statistical computations to predict extreme values of the maximum loads for a given vessel. This includes the ability to define or import wave scatter diagrams, operational profiles, and wave spectra, as well as to compute hull girder RAOs for the most common dominant load parameters (e.g., vertical bending moment). Finally, extreme equivalent regular waves (equivalent design waves) are internally computed and selected for assessment of extreme global loads. The user has a variety of options to add still water loads to the wave-induced loads and to re-balance these components.



Spectral Fatigue Analysis (SFA)

The SFA module provides the ability to perform global fatigue screening of the vessel and introduces additional functionality to the ELA module to compute Stress and Displacement RAOs, define and associate structural groups to SN curves and Stress Concentration Factors (SCFs), and compute fatigue damage based on the Miner cumulative damage principle.

MAESTRO
GLOBAL STRUCTURAL ANALYSIS

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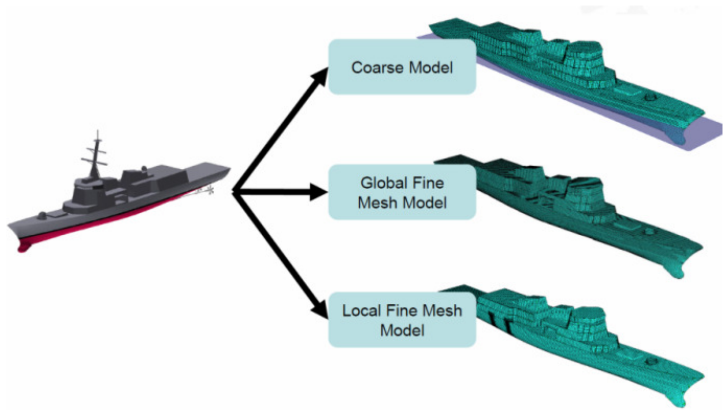
NAPA/MAESTRO Interface

MAESTRO can interface directly with NAPA in order to leverage existing geometry and loading information. The NAPA/MAESTRO Interface (NMI) module allows the designer to import a NAPA/NAPA Steel 3D model, which includes the finite element model (geometry, scantling properties, and finite elements), loading information (longitudinal weight and bending moment distributions, tank boundary, content, and fill definitions, and hydrostatic equilibrium definition), and model hierarchy definitions such as MAESTRO module groups. This interface enables shorter design cycle times by using a single 3D structural design model (from NAPA) that can be re-used as the design matures and is ready for MAESTRO analysis in a matter of minutes.



Natural Frequency Analysis

MAESTRO allows the user to perform a natural frequency analysis and visually identify the dominant global modes. The analysis can be performed in a dry or wet mode, in which the added mass of the seawater is automatically applied to the "wettable" elements based on the immersion condition.

Corrosion Modeling

MAESTRO provides the capability to model corrosion as an additive property associated with a particular load case. The new plate and beam thicknesses are automatically used in the finite element analysis and strength assessment. This enables the user to use a single finite element model throughout the lifecycle of the vessel, easily analyzing "as-is" corrosion information or "what-if" scenarios.

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