

Orca3D™

**Leveraging the power of Rhino
for the naval architect**



Orca3D

User Manual

Version 2.0

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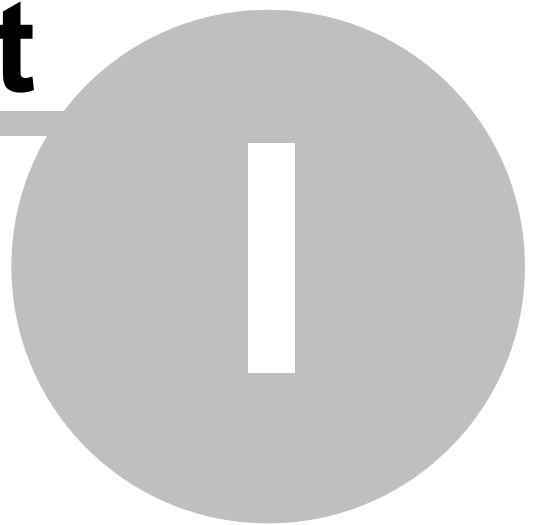
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Part



1 Welcome to Orca3D

Welcome to Orca3D, a comprehensive program that leverages the power of Rhino for the naval architect.

Orca3D is a suite of tools, written as a plug-in for Rhinoceros®, providing powerful naval architectural design and analysis capabilities that are easy to learn and run in a powerful 3D CAD environment.

A completely new and yet familiar program.

While Orca3D was written entirely from scratch, you may find it very familiar. First, it has been designed and written by a group of naval architects that are well known for developing some of the most common and powerful design tools in the industry. With Orca3D, we have been able to create a completely new program, using the latest programming tools and techniques, and the benefit of the experience that can only come from a combined experience of almost 100 years of software development for the marine industry.

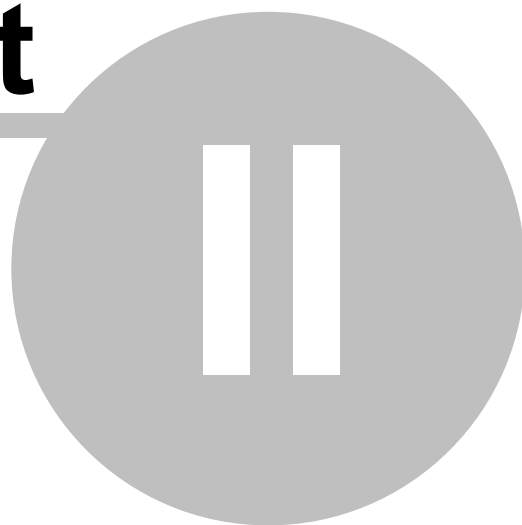
Second, Orca3D has been developed as a plug-in to Rhino, one of the most popular and widely used 3D modeling programs in the world today, especially in the marine industry. Simply put, if you are already comfortable running Rhino, you should be able to be productive with Orca3D immediately.

First class software, backed up by first class support.

Orca3D has been designed and created by a group of naval architects that care about your experience with the software. Simply put, we feel successful when our software can leverage your design talents to create better vessels. If you have questions that can't be answered through this Help or the resources on our website, feel free to contact us, at support@orca3d.com. We enjoy hearing about your projects, your application of Orca3D, and your challenges, and will do our best to help.



Part



2 License Agreement

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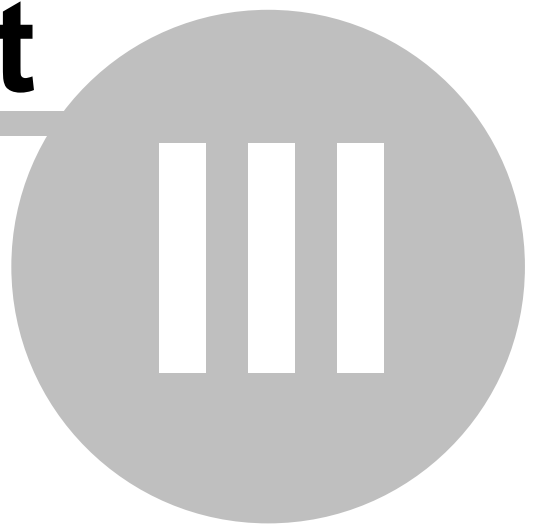
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10/8/2019

Part



3 Latest Updates

Updates and changes to Orca3D are described in the [Release Notes](#)¹⁶, which are also included as part of the installation. They show a complete history of the releases and changes to Orca3D.

3.1 Release Notes

Orca3D Release Notes

Orca3D is a plug-in for designing and analyzing marine structures in Rhino. These release notes describe the status and updates included in the current release of Orca3D.

Orca3D Requirements

- Rhino™ (by McNeel) Installation:
 - Rhino Version 6 or 7 (latest Service Release)
 - Orca3D will not run with Rhino 4 or Rhino 5
- Hardware:
 - See Rhino hardware requirements at http://www.rhino3d.com/system_requirements/
- Operating Systems tested: Windows 7 (Rhino 6 only), 8.1, 10
 - All other Windows operating systems **have not** been tested but may work
 - Mac: The Intel Mac with Boot Camp **has not** been tested but may work
- Operating System Pre-Requisites: (Note - The Orca3D installation will attempt to install any not already on your computer)
 - Microsoft .NET Framework 3.5 SP1 and 4.5.2
 - Microsoft Report Viewer Redistributable 2010
 - Microsoft Visual C++ 2014 Runtime Libraries
- The Offset Table and the CFD Report functions require Microsoft Excel
- Valid license key (without this, Orca3D will operate as a 15-day fully functional evaluation copy)

Release 2.0.22 (August 2021)

New Features

- A new set of Orca3D Grasshopper components have been developed. These components are currently a Work-in-Progress and

are being distributed in WIP form as part of the main Orca3D release. The current set of Grasshopper components are focused on the intact stability functionality of Orca3D. See the Orca3D Help File for additional information about the components along with some examples demonstrating their usage.

Enhanced Features

- Made several changes to the Orca3D Marine CFD user interface including: (a) modified the "Launch Simerics Simulation" form to use a list control instead of a dropdown control so that the complete list of created simulations is visible and set the default selection to the file with the latest creation date/time; (b) implemented a requirement to choose a "Hull Type" in the OrcaSimericsAnalysis command to reduce likelihood of users running with an incorrect (default) Hull Type; (c) modified the CFD face attribution logic to collate all meshing errors for a selected object into one message since the mesher can sometimes create many "bad" meshes for a given Rhino object; (d) added a warning if user chooses CFD Mesh Size below Normal so that the user is aware of the implications of this choice; (e) added help text to the "asymmetric run" check box via a link label.
- Extended the OrcaCreateCFDRender command to allow the user to control the free surface filtering that is applied during the command (i.e., whether to filter and the filter magnitude).
- Made the property list form used for selection of real-time hydrostatics values alphanumerically sorted.

Bug Fixes

- Modified the logic that keeps track of Rhino geometry objects used by Orca3D (i.e., for sectioning) to be more efficient; this addresses long wait times for operations on large numbers of objects (like deleting many points).
- Fixed an issue in Orca3D Marine CFD when calculating the flotation plane for submerged bodies using non-SI units.
- Fixed a bug in stability criteria evaluation when evaluating certain mathematical expressions in the criteria.
- Fixed a string globalization issue in writing a Simerics .spro file with refinement zones.
- Fixed an issue in the Simerics Options form when adjusting the Rhino CAD surface meshes in which any modifications to other parts of the form were lost when returning from the mesh adjustment.
- Modified the OrcaCreateCFDRender command to allow meshes to be selected for the geometry to be rendered.

- Fixed a bug in the scriptable variant of the OrcaHoltropAnalysis command which would prevent it from working properly.
- Fixed a file parsing issue in the CFDRptGenerator when parsing direction vectors from the Simerics .spro file using the local culture instead of the invariant culture
- Fixed a serialization issue related to units for hulls with bulbous bows.

Release 2.0.21 (April 2021)

Orca3D Version 2.0.21 was identical to Version 2.0.20 except that the installer was modified to embed the Microsoft Report Viewer prerequisite installation since the Microsoft download link is no longer supported.

Release 2.0.20 (December 2020)

Our testing has shown that Orca3D 2.0.19 and later works smoothly in Rhino 7, and SubD surfaces are compatible with calculations such as Sections, Hydrostatics & Stability, Speed & Power, and Weight & Cost. Real-time sections currently do not work with SubD models; that is, the sections don't update as a control point is moved, but they do update when the control point is put down.

Enhanced Features

- The Orca3D licensing library from CopyMinder has been updated, providing two new features. The first applies to network licenses of Orca3D, where in past versions starting multiple instances of Rhino on the same computer (and loading Orca3D) would consume multiple network license seats. Now multiple instances on the same computer will only consume a single network license seat. This new feature does require a change to your Orca3D network license. Please contact support@orca3d.com if you would like us to change your license. Installing version 2.0.20 of Orca3D will still work without a change to your license, but the legacy behavior will continue. The second new feature should hopefully reduce the likelihood of false positives being detected by anti-virus software when installing Orca3D for all license types.
- Modified the Orca Hull Assistants to change the "Create Hull" button to a dropdown button that allows you to choose from several creation options including (1) Starboard Hull, Deck, Transom, (2) Port Hull, Deck, Transom, (3) Starboard Hull Only, (4) Port Hull Only, (5) Full Model.
- Extended the logic that saves Orca3D plug-in data (e.g. sections,

water density, etc.) to also write plug-in data when exporting selected parts of your Rhino model to a new 3dm file.

Bug Fixes

- Fixed a bug in the Orca3D cross curves of stability calculation in which the initial waterplane height might not be correct for trimmed surface models.
- Update the Help menu links to reference the new Orca3D website URLs.
- Modified the logic for dynamic sizing of the Orca Hydrostatics form to handle text scaling on high DPI (4K) systems. In earlier versions the form buttons were sometimes cut off in the display.
- Fixed an issue in the Orca CFD Render command in which simulation output files which have user-defined variable columns would cause the render to fail (such as in the case for self-propelled simulations)

Release 2.0.19 (October 2020)

Bug Fixes

- Fixed a couple of globalization issues. One was in the form for defining grid refinement zones used in Orca3D Marine CFD. The other was in the evaluation of stability criteria expressions that reference hydrostatics properties (e.g., Loa).
- Added check for invalid geometry in OrcaCreateCFDRender command.
- Modified the logic for enabling/disabling the propulsor controls in the propeller definition form used in Orca3D Marine CFD. Also fixed a bug in parsing the text field for a constant thrust value in the Simerics Propulsor form.
- Fixed a bug in Orca3D Marine CFD in which self-propelled simulations could potentially run with a different time step than expected.
- Addressed a surface meshing issue in Orca3D Marine CFD in which meshing could fail in specific cases. Also fixed an issue in Orca's mesh preview for hydrostatics and CFD where mesh objects may not be displayed if they had not been pre-computed.
- Fixed an issue to allow dynamic Help to work for Orca3D in Rhino 6.
- Fixed a bug in the Savitsky planing analysis in which the extended output values of Lk, Lc, and d were being incorrectly reported.

Release 2.0.18 (July 2020)

Enhanced Features

- Enhanced the OrcaHydrostatics command by allowing the user to display and adjust the mesh used in the hydrostatics calculation. The Hydrostatics form now includes an "Adjust Meshes" button that behaves similarly to that found in the CFD Options form.
- Extended the form for creating/modifying CFD refinement zones so that the user can directly input the zone geometry definition in addition to specifying it graphically.
- Added a "Reset" button to the Preview Mesh form so the user can reset the meshing values to the initial values when the form was opened.
- Added a new command line option to the Orca3D MSI installer so that quiet installs can be performed without trying to open any UI elements. The option "ShowOrcaInstructions=false" will prevent the final Instructions form from opening.

Bug Fixes

- Fixed a bug in the face attribution logic for the SimericsMP CFD analysis where selecting objects for face attribution that were not part of the original object(s) selected for the CFD analysis could cause problems in the UI.
- Modified the SimericsMP CFD command so that all 3 moments of inertia are exported in case the user is performing an analysis with user-defined degrees-of-freedom.
- Also include a "CG" text dot when a user is performing a hydrostatics analysis and the "Transform Model to Resultant Condition" option is selected.
- Fixed a bug in stability criteria analysis when no angle of vanishing stability is found by giving the user the option to use 180 deg (full inversion) as GZ0. Note that this analysis is also used in the STIX analysis command.

Release 2.0.17 (May 2020)

New Features

- A new command, OrcaCreateCFDRender, was added. This command generates a rendered viewport of the selected Rhino model geometry together with the water surface. Two types of renders are supported. The first shows the model floating at static equilibrium (zero speed) based on the condition setup for the CFD simulation. The second shows the model in its dynamic heave and pitch attitude

along with the water free surface mesh extracted from the CFD simulation.

- Added two new options for the hull type used by the CFD marine template. In addition to displacement hulls, planing hulls, and high-speed displacement hulls, Orca3D now allows the user to specify "Low-Speed Hull" and "Submerged Body" hull types for the simulation. The low-speed hull type may be appropriate for full, low L/B hull forms running at lower Froude numbers where the ship-generated waves are relatively small (and therefore the wave-making resistance is a relatively small part of the total resistance). The marine template makes adjustments to the simulation for these conditions to improve resolution of the free surface waves. The submerged-body hull type allows users to analyze models without a free surface. This hull type is only available with the "Premium" version of Orca3D Marine CFD. Contact support@orca3d.com with any questions about obtaining the Premium version.

Enhanced Features

- Extended the Savitsky planing hull analysis to include additional parameters in the generated report (wetted keel length, wetted chine length, transom keel depth, critical trim angle for porpoising stability).
- Modified the Savitsky planing hull analysis so that if a computation fails at one speed do to a failure to find the equilibrium trim angle, that error is reported but the analysis continues instead of ending the analysis with no results.

Bug Fixes

- Fixed a reporting bug in stability criteria evaluation in which the base hydrostatics condition for a rollover calc was not first in the list of reported hydrostatics and therefore a heeled condition was being reported. (Note this did not affect the overall evaluation results.)

Release 2.0.16 (April 2020)

Enhanced Features

- Modified the hydrostatics command behavior so that when the user chooses the option to "Add Plane(s) Representing Water Surface" the Rhino objects/groups containing the float planes, text dots, and sectional area curves are created on sublayers of the primary hydrostatics output layer in order to allow easier visualization and

identification of the output.

- Added the ability to copy/paste data to/from the clipboard into the custom conditions control in the Hydrostatic form. A typical source of this data might be a spreadsheet table or a CSV file. When pasting, the data must have 10 columns matching the format of the data in the grid (including empty cells/data in columns where no numbers should be copied). After placing the data to copy into the Windows clipboard, right click on the custom conditions grid control and choose Paste from the pop-up menu.

Bug Fixes

- Fixed an issue in the RIB hull assistant that was preventing the transom surface from being created
- Fixed an issue in the Orca STIX calculation command that affected the beam-displacement factor, FBD
- Fixed an issue in Orca control points that sometimes prevented the control polygon line segments from being drawn
- Fixed an issue in the scriptable version of the OrcaHydrostatics command that caused the pop-up report to be blank if ShowReport=yes

Release 2.0.15 (February 2020)

Enhanced Features

- Extended the Simerics CFD interface to automatically create XY plots for heave/pitch and resistance/EHP during generation of the CFD simulation. This requires Simerics-MP version 5.0.9 or later.
- Added the ability for the user to modify the gravitational constant used for hydrostatics computations.
- Modified the behavior of the interactive hull assistants so that the view is not zoomed to extents as changes are made to the assistant.

Bug Fixes

- Modified the scriptable version of the planing hull assistant to include the ability to adjust the chine vertically or transversely (which is already exposed in the interactive version of the assistant).
- Fixed a bug in which copying Rhino objects that contain Orca3D CFD user data would create invalid user data on the copied objects.

Release 2.0.14 (January 2020)

Enhanced Features

- Added digital signature to Orca3D installation to confirm software author and guarantee that the code has not been altered or corrupted.

Bug Fixes

- Fixed an issue in some of the Orca3D hull assistants related to non-US keyboard settings.
- Fixed an issue in Orca3D design hydrostatics which occurred for free float calculations when an initial float plane height of 0 is not suitable.
- Fixed an issue in the Orca3D CFD analysis form where the propulsor controls were not functioning correctly.

Release 2.0.13 (December 2019)**Bug Fixes**

- Modifications to NavCad export command related to mesh normal direction and meshing parameters.
- Fixed a bug when defining propeller performance for self-propelled CFD simulations in which selecting user-defined Kt/Kq or constant thrust/torque options would not allow the user to continue.
- Addressed an issue in the CFD report command, caused by an update to Excel, in which use of named ranges in formulas can result in “#SPILL” errors in the report.

Release 2.0.12 (November 2019)**Enhanced Features**

- Added view definitions of standard orthogonal views in SimericsMP so that the user can easily select Bodyplan, Profile, and Planview views
- Extended the OrcaCreateStrake lifting strake command to include the option to have taper on aft end of strake (in addition to the forward end).

Bug Fixes

- Fixed a bug in hydrostatics calculations that could occur in specific cases when the water density is changed. This would only impact free-float calculations and could result either in a hydrostatics

calculation failure or an output condition whose weight did not match the input weight.

- Fixed a bug in NavCad export command related to correct transformation of the hull geometry for NavCad.
- Fixed a bug in the Simerics CFD report where C_f and C_r could be negative depending on model orientation; also handle the case where more than one .spro file exists in a folder where the integrals text file exists.
- Fixed a bug in the Simerics propeller plot variable definitions

Release 2.0.11 (October 2019)

New Features:

- A new command, OrcaNavCadAnalysis, was created that allows Orca3D to interface with the speed/power prediction program, NavCad, developed by HydroComp, Inc. This command requires geometry, hydrostatics, and other input from the Rhino model then exports this information to a script that can be imported into NavCad where additional analyses can be performed. *This command is in Work-in-Progress (WIP) status. Please provide feedback on any issues related to this function.*
- Extended the OrcaSimericsAnalysis CFD command to include the ability to specify wake fraction input that is used for self-propelled simulations. The wake fraction can be a single value or a speed-dependent set of values, and it is used to determine the nominal inflow velocity into the actuator disk representation of the propeller.

Enhanced Features:

- Modified the OrcaSimericsAnalysis CFD command to include a new face type classification. The "appendage" face classification can be used to exclude one or more model faces from the "hull" bounding box calculation during CFD grid refinement. Faces classified as appendages still have their own grid refinement zone around them, but in the case where an appendage extends well outside of the bounding box of the rest of the hull (such as a fin keel on a sailboat or a foil on a hydrofoil) this avoids unnecessary grid refinement caused by an artificially large hull bounding box.
- Modified the form to assign Orca stock materials to geometry so that the dropdown combobox for selecting the material is sorted alphanumerically. This makes it more convenient to find the correct material when the list is quite long.

- Modified Orca reports (hydrostatics, speed/power, weight/cost) so that they open in front of main Rhino window.

Bug Fixes

- Fixed a bug in stability criteria evaluation for computing required freeboard to deck edge when the design condition does not have "Mirror" turned on.
- Fixed a bug in the OrcaCreateStrake command where the projected base strake curve might not match the input curve when selecting a custom curve (due to a tolerance issue).

Release 2.0.10 (July 2019)

Bug Fixes:

- Fixed a bug in the Orca3D Marine CFD Python script that is automatically generated. For now, all simulations will run to completion without any convergence checking to avoid premature ending of simulations.

Release 2.0.9 (June 2019)

Enhanced Features:

- Modified the OrcaSimericsAnalysis CFD command to take advantage of new functionality in SimericsMP 5.0. This included adding new CFD grid density options and adding an input to control the number of saved CFD results files. This input value currently defaults to 4 so that the user will have 4 .sres files when running the simulation, which allows the user to get back to the most recently saved point in the simulation if a failure or reboot occurs during the simulation.
- Added a new button in the hydrostatics form to allow the user to both create and select a flotation plane graphically instead of having to first create the plane before running the hydrostatics command.
- Extended the offset table command to include 3D curves that the user selects (such as chine or deck edge curves) to the offset table output. To include these curves the user must first create them if necessary by extracting them from the surface model and then select the offset table option to specify curves to include and select them along with stations, waterlines, and buttock curves.

Bug Fixes:

- Fixed a bug in the OrcaCreateFloatPlane command in which plane creation could fail if the selected reference points were on a

perfectly horizontal plane.

- Fixed a bug in setting flotation plane sinkage, trim, and heel values in hydrostatics form by picking a plane surface that occurred with certain model orientations.
- Fixed a bug in decimal separator localization in the Simerics propeller performance input form.
- Fixed an issue in defining the Orca3D Design Condition where it was possible to have objects on hidden/locked layers that were part of the design condition even after the user chose to re-select objects in the condition.

Release 2.0.8 (April 2019)

Enhanced Features:

- Modified the hydrostatics command so that when the user chooses the option to “Add Plane(s) Representing Water Surface”, an annotation dot is included representing the Center of Gravity location. This assumes that the CG is known either because it was entered as part of is an equilibrium free float calculation or was computed from a fixed flotation plane calculation with a VCG input for a righting arm calculation.
- Added ability to graphically display refinement zones for Orca3D Marine CFD. The “Refinement Zones” tab now contains a toolbar button to review the currently defined refinement zones. Zones that are inactive are shown grayed out.

Bug Fixes:

- Fixed a units-related bug in the creation/editing of refinement zones for Orca3D Marine CFD.
- Fixed a bug in how cylindrical refinement zones were being created/persisted.
- Fixed a bug in the Orca3D Marine CFD Python script that is automatically generated. This bug was related to convergence checking during the simulation run.
- Modified the Orca3D offset table command to improve error handling.
- Fixed an issue in the Orca3D Marine CFD report command in which Simerics project files that contain an apostrophe would create invalid cell references to imported file worksheets.

Release 2.0.7 (March 2019)

New Features:

- A new command, OrcaCreateFloatPlane, was added to allow the user to define a plane (representing a measured flotation plane) from one, two, or three freeboard or draft measurements. For each measurement, the command requests input of the reference location of the measurement (such as a transom corner or deck location where the measurement was made from) and the measurement to the water surface. If only one point is specified, the flotation plane is assumed to be a zero trim/zero heel plane. If two points are specified, the plane is assumed to be either zero trim or zero heel depending on the relationship of the first and second reference points. Finally, if three measurement points are specified a general plane with heel and trim is created. The resulting plane is added to the Rhino model so that it can be used as input to a hydrostatics calculation.
- Added the ability to define axis-aligned box and cylindrical refinement zones for CFD analysis in Rhino/Orca3D without having to define them in SimericsMP directly. This functionality can be enabled from the OrcaSimericsAnalysis command form by clicking on the "Options..." button and enabling the "Use Grid Refinement Zones" checkbox. After doing this the main command form will include a new Refinement Zones tab within which the user can create new refinement zones using Rhino UI interaction.

Enhanced Features:

- Modified the OrcaHydrostatics command to allow defining a flotation plane for hydrostatics by selecting a planar surface in the Rhino model. The form associated with the hydrostatics command has a new "Select Float Plane" button which allows the user to select a planar surface in the model. The sinkage, trim, and heel for this flotation plane is automatically computed and entered as input once the plane is selected.
- Modified the automatically-generated Python script for running multiple simulation speeds with Orca3D Marine CFD so that the CFD grid file is automatically saved before running the simulation. This prevents the possibility of inadvertently generating a slightly different grid file later that could prevent loading of saved results.
- Modified the form for the OrcaSimericsAnalysis command to move less commonly-used command options into an Options form accessed from the main form.

Bug Fixes:

- Fixed a bug in the OrcaOffsetTable command that prevented an offset table from being created if there were no waterlines or no

buttocks defined.

- Fixed a bug in Holtrop analysis output where the reported margin was 100 times larger than the input margin (and the margin actually used in the analysis).
- Fixed a localization bug in the OrcaSimericsAnalysis command in which those users who have a comma as the decimal separator for floating point values would have the flotation plane in the wrong place when creating a Simerics project because it was not parsing the VCG correctly.
- Also fixed a localization bug in the OrcaCreateCfdReport command which caused reporting problems for users with a comma as the decimal separator.
- Modified model-ship correlation allowance, C_a , calculation in the OrcaCreateCfdReport command to impose upper and lower limits (0.0008/0.0002) on C_a to account especially for smaller vessels that might be analyzed. Also adjusted R_a and C_t to be based on Swet excluding S_{app} .

Release 2.0.6 (January 2019)

Enhanced Features:

- Modified hydrostatics report to include righting moment (in addition to righting arm) if it is not a stability criteria evaluation analysis.

Bug Fixes:

- Several modifications with respect to heeling arm definition and persistence including allowing for a non-integer power in the cosine distribution for custom heeling arms, fixing a bug that prevented custom heeling arm with user-specified values from being created, and fixing a serialization bug applicable to all heeling arms.
- Fixed a bug in the bulbous bow functionality associated with the ship hull assistant in which a non-default model orientation could cause the bulb to be drawn in the wrong orientation. Also modified the bulb definition to be independent of draft by changing the bulb height input from a non-dimensional height as a fraction of draft to a dimensional height above baseline. With this change the draft input can still be used to set the reference height in the ship hull assistant. Fixed a units display issue in the ship hull assistant form for bulb dimensional input parameters.

Release 2.0.5 (January 2019)

Enhanced Features:

- Added FastShip “.srf” file format to the list of supported file types.

Bug Fixes:

- Fixed a bug in retrieving saved hull and bulb parameter values from saved ship hull assistants after the addition of the bulbous bow creation capability.
- Fixed a units bug in the FastShip .pex file import.
- Fixed a bug in which the Rhino “cut” command would cause an Orca error dialog to pop-up.

Release 2.0.4 (January 2019)**Enhanced Features:**

- Extended the OrcaSimericsAnalysis command for performing CFD self-propelled simulations to include the option to define propeller performance based on the Gawn-Burrill propeller series (in the non-cavitating operating regime). The Gawn-Burrill series consists of 3 and 4-bladed propellers with segmental sections defined by flat faces and circular backs that are generally considered to be representative of the propeller blade shapes used in the small craft recreational boat industry.

Bug Fixes:

- Fixed a bug in the sailboat hull assistant that could cause forward waterline endings below the forefoot to meet centerline at non-perpendicular angle.
- Modified lines drawing command so that the current layer that existed before creating the lines drawing is restored after the command successfully completes.
- Modified the offset table command to implement a more robust method to retrieve the Orca sections used for the table.
- Fixed a bug in the Orca installer that could cause an error when installing VC++ 14 Runtime Libraries.

Release 2.0.3 (December 2018)**New Features:**

- Orca now supports import and export of Precal hull offset files. The import functionality is provided through the standard Rhino file open/import dialog, and export is provided through the OrcaExportCurves command.

Bug Fixes:

- Fixed a bug in the Orca installer that could cause a CopyMinder licensing issue when replacing the V2.0 WIP with the new release build.

Release 2.0.2 (December 2018)

This is the initial full release of Orca3D V2 targeting Rhinoceros 6.

New Features:

- A new command, OrcaCreateStrake, was added to provide a convenient method for creating lifting strakes on planing hulls. The command allows the user to define the base curve for the lifting strake as an iso-parametric curve on the surface, a planar section curve on the surface, or any user-defined surface curve. The strake cross-section geometry, longitudinal extent, and taper characteristics can also be defined. The resulting strake geometry can be optionally joined to the hull surface.
- A new Orca3D Hull Assistant has been added for creating developable hull shapes. This new assistant uses Rhino's developable loft functionality to generate hull forms based on user-controlled deck sheer, chine, and bottom profile curves. An optional chine flat may be included. Note that due to a bug in Rhino 6 SR11, the chine flat surface creation may fail. McNeel is expected to address this issue in SR 12. In the meantime, the user can manually construct a surface between the two curves bordering the chine flat after the rest of the geometry has been created.

Enhanced Features:

- The Orca3D Ship Hull Assistant has been extended to allow incorporation of bulbous bows into the generated hull geometry. If the option to create a bulb is selected, the user can control the length, height, width, and cross-section shape of the bulb. The resulting bulb geometry is integrated into the hull as part of the same surface.
- OrcaCreateCfdReport, was enhanced to include computation and plotting of non-dimensional drag coefficients (C_f , C_r) along with the computation of the ITTC 1957 C_f values for comparison. Added a table of definitions to the report output. Modified the user interface for creating the report to allow multi-select of simulations to include/exclude from the report, making selection easier. Added color-coding of worksheet cells that are expected user input and

- protected the workbook to avoid inadvertent modification.
- Added RhinoScript access to certain Orca3D objects, such as the most recent stability calculation results.
- Added the ability to define Orca3D section locations interactively using mouse selections.

Bug Fixes:

- Fixed a bug in the OrcaSimericsAnalysis command to address an issue when running self-propelled simulations across multiple propeller RPM values.
- Fixed a bug in the OrcaPlaningAnalysis command related to computing deadrise angle (which had caused zero-deadrise hulls to fail in the command).
- Fixed a bug in which Rhino block instance geometry was not properly handled for hydrostatics and weight/cost component calculations.

Work-In-Progress Release 2.0 (October 2018)

- Orca3D version 2.0 targets Rhinoceros version 6. This is the initial WIP release of Orca3D v2. Note that since Rhino 6 only targets 64-bit platforms, there is now only a 64-bit version of Orca3D.
- The licensing system that was used in Orca3D Version 1.x (Nalpeiron) is being replaced by a system called CopyMinder. The V2 WIP will initially have two versions, one for each licensing system. We will be phasing out the Nalpeiron system, and after 12/15/2018 you will no longer be able to de-activate and activate Nalpeiron licenses.. You may contact us at sales@orca3d.com to receive your CopyMinder License Key. Please be sure to include your Nalpeiron License Code with your request.
- The HydroComp Drag Library has been replaced by our own for the Savitsky and Holtrop resistance methods. Our library has been thoroughly tested using the published sources. However, due to differences in interpretation of the methods, you may see small differences (generally <5%) in the results for the same hull between Orca3D Version 1 and Version 2.

Work-In-Progress Release 1.4 (March 2018)

- As a result of a change in ownership, Orca3D is now copyrighted under Orca3D, LLC. All Orca3D libraries have been modified to

reflect this new ownership.

New Features:

- A new command, OrcaCreateCfdReport, was added to allow extracting results from Simerics Marine Simulations to generate a report. The report is generated in Microsoft Excel and requires Excel 2016 or later. The principal intended use of the report is to summarize results across ship speeds, although it should work for a single speed. The command is still a work-in-progress, and new features are expected to be added with subsequent releases.

Enhanced Features:

- Extended the Simerics CFD analysis command to allow user-defined face attribution. Although faces must still be classified as “hull” faces or “deck” faces for gridding purposes, the ability to define new face attributes allows post-processing of forces and moments based on user-defined boundaries.

Bug Fixes:

- Fixed a bug in the calculation of propeller open water coefficients for B-series propellers in Simerics CFD simulations. The magnitude of the error in the coefficients was dependent on the specific propeller characteristics.
- Fixed a bug in the Simerics CFD analysis command in which the Simerics 3D graphical view had mirroring turned on even for asymmetric simulations.

Work-In-Progress Release 1.4 (October 2017)**Bug Fixes:**

- Fixed multiple forms for high-resolution scaling.

Work-In-Progress Release 1.4 (September 2017)**Enhanced Features:**

- Modified Orca3D Simerics Marine Simulation meshing options to allow the user to choose “coarse”, “normal”, or “fine” Simerics meshing.
- Extended the Orca3D Simerics Marine Simulation command so that keyboard input is supported during interactive definition of propeller geometry.

Bug Fixes:

- Fixed a bug in the Orca3D Simerics Marine Simulation analysis command related to defining custom propeller Kt/Kq values.
- Fixed a bug in the display of Orca3D Simerics Marine Simulation face attributes which caused it to be very slow for large meshes.
- Modified network installation to target "All Users"

Work-In-Progress Release 1.4 (June 2017)**Enhanced Features:**

- Extended the Orca3D Simerics Marine Simulation behavior to include a new "High Speed Displacement" template primarily for fast displacement hulls with transom sterns.

Bug Fixes:

- Fixed a units issue in the Orca3D Simerics Marine Simulation interface when using constant thrust/torque propeller option.

Work-In-Progress Release 1.4 (May 2017)**Enhanced Features:**

- Modified the Orca3D Simerics Marine Simulation behavior so that when creating self-propelled simulations, the subfolder name containing the simulation includes the propulsor rpm.

Bug Fixes:

- In the Orca3D Simerics Marine Simulation interface:
 - Fixed a bug for self-propelled runs using constant thrust and torque input which resulted in zero thrust being produced.
 - Fixed a bug when specifying a simulation path that contains subfolders with restricted access which could cause Rhino to crash.
 - Fixed a bug related to using the Orca3D Marine CFD interface with non-US keyboard settings (when the decimal separator is not ".").
 - Fixed a bug in the Orca3D Marine CFD form in which floating point values specified using scientific notation were not being parsed properly and were thus being indicated as being invalid numbers.
 - Modified the behavior so that in "Adjust Meshes" when the user clicks the "Accept" button, the changes are accepted

even if the user has not yet clicked the “Preview” button.

Work-In-Progress Release 1.4 (April 2017)

Enhanced Features:

- In the Orca3D Simerics Marine Simulation interface:
 - Implemented the ability to create self-propelled Simerics simulations by defining one or more propulsors in the model.
 - Modified the default Rhino meshing parameters for meshing the surface geometry for transfer to Simerics. Also implemented the ability to adjust the surface mesh created by the Rhino mesher for export to Simerics as well as the ability to display mesh faces whose area or aspect ratio are beyond a user-specified value.
 - Implemented the ability to accept closed Rhino mesh geometry as input to the marine simulation command. Previously only closed polysurface geometry was permitted. In addition to allowing users to create the marine simulation from native mesh geometry, this also allows users to create a mesh from a closed polysurface using native Rhino tools and perform any desired pre-processing on the mesh.
 - Added the ability to select more than one closed body for the marine simulation. This allows users modeling catamarans to avoid having to model the connecting structure as long as it has no significant effect on the simulation.
 - Added the ability to control the CFD mesh density and size of the domain created in the Simerics analysis. Also added logic to estimate the required time step and simulation length. This new functionality is only used if the user chooses to override the Simerics default values.
 - Implemented persistence of all input to the Orca3D Marine CFD command.
 - Made numerous modifications to the Orca3D Marine CFD user input form to make it simpler to understand and use.

Bug Fixes:

- In the Orca3D Simerics Marine Simulation interface:
 - Fixed several unit-related bugs when operating in non-SI unit systems
 - Fixed bugs related to model orientations other than the default x-longitudinal, z-vertical orientation
 - Fixed a bug in which the Rhino surface mesh of a closed polysurface was not necessarily a closed mesh.
- Fixed a bug in the Orca weight/cost calculator where changes to a

weight item name were not persisted.

Work-In-Progress Release 1.4 (January 2017)

Bug Fixes:

- In the Orca3D Simerics interface:
 - Fixed selection of faces so that they un-highlight after assigning the face type
 - Fixed validation of hull type and analysis type
 - Fixed bugs in applying Orca3D's forward and up vectors within the Orca3dSimericsCommand to be consistent with the rest of Orca3D
 - Fixed issue with template file names when only one speed entered

Work-In-Progress Release 1.4 (November 2016)

Bug Fixes:

- Fixed regional settings bug affecting stability criteria hydrostatics

Work-In-Progress Release 1.4 (October 2016)

New Features:

- A new command was developed to interface Orca3D with the Simerics Multi-Physics (SimericsMP) Computational Fluid Dynamics (CFD) analysis tool. The command, OrcaSimericsAnalysis, has the ability to use the Design Condition or any user defined loading condition to compute the model's hydrostatics and world placement. The hull model must be a closed, solid body, and the user must attribute the Faces of the model as belonging to the Deck, Hull, or Transom. The command exports the model as custom STL files, and then creates the SimericsMP simulation files based on a Simerics Template and the analysis type (displacement or planing) for each speed to be analyzed. Finally, the command allows the user to launch SimericsMP with a selected simulation file. SimericsMP will open the simulation file and will automatically generate surface meshes and volume grids that are suitable for the requested simulation.

Enhanced Features:

- Split the developable hull assistant extension curve into unique

forward and aft controls.

Bug Fixes:

- Fixed multiple bugs causing instability in the developable hull assistant. Improved handling of non-developable input data.

Work-In-Progress Release 1.4 (July 2016)

Please note that this release no longer supports Rhino v4. This and future Orca3D WIP releases require Rhino v5 (SR12 or later).

Enhanced Features:

- Added manual override for stability criteria evaluation angle limits.
- Added flat bottom control to developable hull assistant.

Bug Fixes:

- Fixed multiple bugs causing instability in the developable hull assistant.
- Addressed a unit persistence error in developable hull assistant.
- Improved error handling in cross curves of stability form.
- Fixed installation location of CommonDataFolder for 64-bit network client.

Work-In-Progress Release 1.4 (March 2016)

Please note that this release no longer supports Rhino v4. This and future Orca3D WIP releases require Rhino v5 (SR12 or later).

Enhanced Features:

- Incorporated an updated drag library from HydroComp, Inc.
- Updated intact hydrostatics reports to include a table of values when running cross curves evaluation.
- Added design hydrostatic condition import to the general hydrostatics form.

Bug Fixes:

- Removed dependency on Visual Studio Power Packs that was causing installation issues for some Windows 8/8.1/10 users.
- Fixed culture-specific list evaluation in planing hull wizard and RIB hull wizard causing improper behavior of the slider controls.
- Fixed chine determination for single surface hulls in lines drawing evaluation.
- Fixed bug where hull modifications using Orca3D tools may

- unintentionally split a surface along all creases.
- Fixed solver bug in stability criteria leading to failed stability analysis.
- Fixed broken help file hyperlinks to reflect changes to the Orca3D website structure.
- Fixed bug that caused the loss of saved developable hull assistant settings when migrating between the Orca3D release and WIP versions.

Work-In-Progress Release 1.4 (September 2015)

Please note that this release no longer supports Rhino version 4. This and future Orca3D WIP releases require Rhino version 5 (SR 12 or higher for the 64-bit version of Orca3D).

Bug Fixes:

- Fixed a bug in the Orca3D stability criteria evaluation related to retrieving deck edge curves used in computing freeboard.
- Made additional changes to lines drawing command behavior related to persisting form settings and chine drawing.
- Modified developable hull assistant form so that the "Create Hull" button is not the default button. This addresses a behavioral issue in which users clicking <Enter> to accept a text field input caused the hull to be created before they were finished.

Work-In-Progress Release 1.4 (May 2015)

Please note that this release no longer supports Rhino version 4. This and future Orca3D WIP releases require Rhino version 5 (SR 10 or higher for the 64-bit version of Orca3D).

New Features:

- A new command, OrcaCrossCurves, has been added to allow the user to compute and report traditional cross curves of stability. See the Orca3D Help File for details on the use of this new command.

Enhanced Features:

- Extended the Orca3D hydrostatics CSV file output to include extended information for the rollover conditions when the option to include full output is selected.
- Made additional Orca3D commands scriptable including

OrcaPointsOn, OrcaPointsOfInterest, OrcaCreateWeightCostPoint, OrcaProperties, OrcaInsertNet, OrcaInsertChine, OrcaWrapCorner, OrcaExportMeshes, OrcaCreatePlate.

- Modified the layer name used for the output of the hydrostatics floatation plane to include the condition the plane is associated with.
- Modified the Orca3D hull assistant form behavior so that the <Enter> key does not automatically create the hull geometry to avoid inadvertent hull creation. The user must click OK to create the hull.
- Implemented several Orca3D installation and licensing changes. Updated licensing files and services to the latest versions. Modified network-licensed product installation instructions and some of the network installation files to reduce likelihood of inadvertently running the incorrect installation. Packaged license diagnostic utilities in installation.

Bug Fixes:

- Fixed a bug in the Orca weight/cost manager in which directly editing a value in the manager grid control did not apply the proper units conversion.
- Fixed a bug in OrcaRemoveNet in which the surface normal was sometimes inadvertently flipped.
- Added call to set the “modified flag” of the current Rhino document for certain Orca3D commands.
- Fixed a bug in some Orca commands in which the general Rhino application setting, m_bSplitCreasedSurfaces, was not being properly reset to its original state at the command conclusion; this affected the following commands, OrcaCreateFoil, OrcaCreateRIB, OrcaInsertChine, OrcaInsertNet, OrcaRemoveNet, OrcaCreatePlaningHull, OrcaHullAssistant.
- Improved error handling in OrcaHoltropAnalysis so that certain geometries (e.g., catamarans) in which the transom finding logic could cause a crash are now more robust.
- Addressed a bug in Orca weight/cost reports where CG subtotal could be reported as a NaN instead of zero for zero weight totals.
- Applied several lines drawing bug fixes including an issue in using “selected curves” for the drawing, a problem where changing section locations or reading in a new model after a lines drawing was created did not allow future lines drawings to reflect the new sections, an issue where the bodyplan split location was being ignored, and an issue in which chine lines were not appearing in the drawing.
- Fixed bug in importing a Rhino model containing Orca3D units

information into the current model that contains different Orca units.

- Added logic to prevent Orca3D sections that were made invisible through the Rhino layer control from reappearing during interactive Orca3D control point manipulation.
- Fixed a bug in the OrcaCreateWeightCostPoint which had crept into an earlier May 2015 WIP release in which the assignment of a point material was not being properly handled.

Work-In-Progress Release 1.4 (October 2014)

Please note that this release no longer supports Rhino version 4. This and future Orca3D WIP releases require Rhino version 5.

Enhanced Features:

- Rollover sub-report now shows heeling arm if applicable
- Points of interest now shown in same table as righting arm
- Added more helpful suggestions to the Planing Analysis error message

New Features:

- Added new command and report for ISO 12217-2 STIX calculation. This calculation calculates the 6.4 Minimum Righting Energy value and category, the 6.5 Angle of Vanishing Stability value and category, and the 6.6 Stability Index (STIX) factors, values, and design category.

Bug Fixes:

- Exponential notation in Stability Criteria Analysis changed from `Math.pow(x,y)` to `x^y`
- Frequent null reference exception in Developable Hull Assistant corrected

Work-In-Progress Release 1.4 (April 2014)

Please note that this release no longer supports Rhino version 4. This and future Orca3D WIP releases require Rhino version 5.

New Features:

- Added a new hull assistant for creating developable surface models. This assistant takes a new approach to the developable surface problem and is based on a composition of conic and cylindrical surface patches that is guaranteed to form a mathematically

developable surface model. See the Orca3D Help File for a detailed discussion of the new developable surface functionality.

Bug Fixes:

- Fixed a bug in the Orca tree view which had caused a crash in Rhino 5.
- Fixed some error condition message handling in Orca3D hydrostatics.
- Addressed a units and persistence issue related to overriding the initial plane height for free float hydrostatics in the Orca3D design condition.

Work-In-Progress Release 1.4 (January 2014)

Please note that this release requires Rhino version 4 service release 9 or later.

Enhanced Features:

- Extended command OrcaSelWeightCost to permit selection of weight/cost items by material type (point, curve, surface, solid, none) or by material name.
- Updated licensing file versions and modified network-licensed product installation to install both 32-bit and 64-bit client setup files.

Bug Fixes:

- Fixed a bug in the Orca hydrostatics report in which the TCB and TCF plot label could inadvertently read 10^0 .

Work-In-Progress Release 1.4 (June 2013)

Please note that this release requires Rhino version 4 service release 9 or later.

New Features:

- Re-enabled intact stability criteria evaluation and longitudinal strength functionality.

Release 1.3.1 (July 2013)

Please note that this release requires Rhino version 4 service release 9 or

later, or Rhino version 5 service release 3 or later.

Bug Fixes:

- Fixed a bug in computing weight/cost properties for a block instance that contains a solid and that was created by mirroring another block instance.
- Fixed a bug in the scriptable version of OrcaProperties where unit settings were not being applied. This does not affect the interactive version of the command.

Release 1.3 (June 2013)

Please note that this release requires Rhino version 4 service release 9 or later, or Rhino version 5 service release 3 or later.

New Features:

- See new features list in release notes for 1.3 WIPs below

Enhanced Features:

- See enhanced features in release notes for 1.3 WIPs below
- Added an Orca3D property setting to provide the option to allow real-time section calculations to use mesh-based sectioning (an approximate approach that has always been done in the past versions of Orca3D) or alternatively to use surface-based real-time sectioning (which in past version had been used only on the final section update, which occurs when a control point move is completed). Rhino 5 in particular has a faster contouring capability which makes the use of surface-based real-time sectioning practical in most cases. The default value for this option is to use surface-based sectioning.
- Updated Orca3D licensing service and associated files to better support Windows 8.
- Added Short Tons to the available units options for Weight and Force

Bug Fixes:

- See bug fix list in release notes for 1.3 WIPs below
- Modified OrcaLinesDrawing command by adding new layer for ship outlines (shear, stem, etc) to fix behavior where these lines don't show up.
- Modified how hydrostatics reports transverse and longitudinal GM to address potential localization issues (use of decimal point vs. comma) when exporting hydrostatics to CSV or Excel.

- Modified resistance calculation routines to handle potential error conditions in the resistance sensitivity analysis.
- Fixed a bug that prevented the FastShip file type from showing up in the list of files types to open/import in Rhino 5.
- Improved handling of potential error condition when exporting curves to IDF via the OrcaExportCurves command.
- Fixed a bug in OrcaWrapCorner command in which the surface normal direction was inadvertently flipped in applying the corner wrap; also made a change to computation of corner wrap point location to accommodate different surface orders in the two parametric directions
- Modified the hydrostatics and stability form so that the Orca Weight Calculator is available with a Level 1 license.
- Modified the Orca3D tree to properly display layer visibility in Rhino 5. A limitation in the current Rhino 5 SDK limits the ability of third party developers to display/set sub-layer visibility. This is expected to be addressed in the next Rhino service release. A new Orca3D release is expected to be issued subsequent to that service release which will address sub-layer visibility.

Work-In-Progress Release 1.3 (March 2012)

Please note that this release requires Rhino version 4 service release 9 or later.

Enhanced Features:

- Many changes related to stability criteria evaluation to improve usability including a refactoring of the user interface. See the help file for more details.
- Made minor changes to the grouping functionality on the weight/cost report to improve readability.

Bug Fixes:

- Incorporated a new drag library from HydroComp that fixes an issue in the porpoising calculation.

Work-In-Progress Release 1.3 (November 2012)

Please note that this release requires Rhino version 4 service release 9 or later.

New Features:

- **64-bit Floating Network License** – the Orca3D network floating license is now available as a 64-bit capability so that users of Rhino 5 (64-bit) can use this functionality.

Enhanced Features:

- Added scriptable versions of OrcaAssignWeightCost and OrcaMergeStockMaterialLibrary commands.
- Modified RhinoMarine -> Orca3D translator to include 64-bit support.
- Modified the stability criteria evaluation to recognize hydrostatics-based keywords for evaluation.

Bug Fixes:

- Fixed bug in Orca3D lines drawing command which could sometimes a Rhino crash.
- Addressed several unit globalization issues.
- Addressed several issues in the stability criteria evaluation functionality including non-standard model orientations, keyboard settings, and adding "From" and redefining "Between" in the criteria limits.
- Modified Orca3D to handle possible corrupted application settings file (e.g., custom report settings). The settings file can become corrupt if Rhino crashes while the file is being written to disk. The current logic will still require a restart of Rhino.
- Addressed an issue in the Hull Assistant Library which sometimes caused the command to load slowly on first execution.

Work-In-Progress Release 1.3 (September 2012)

Please note that this release requires Rhino version 4 service release 9 or later.

New Features:

- **Developable Hull Assistant** - a new developable hull assistant has been started. This assistant, which is still under development, is based off of the planing hull assistant but is intended to allow the user to create fully developable hull shapes. The current implementation uses the Rhino surface lofting functionality to create the developable surfaces. However we expect to implement alternative methodologies for developable surface creation.

Enhanced Features:

- **Longitudinal Strength**
 - Numerous extensions have been made to the new Orca3D longitudinal strength functionality. These include the ability to define the sectional modulus either as a function of longitudinal location or as a single constant value and the ability to compute the longitudinal distribution of bending stress. An initial output capability (CSV format only) has been included. The layout of the longitudinal strength form has been significantly improved. An auto-rebalance capability had been implemented.
- **Hydrostatics**
 - Modified the logic that inserts the flotation plane to use a unique layer name for the plane object.
 - Modified the scriptable version of the hydrostatics command to include an argument which optionally allows the user to show the hydrostatics report. Also allow surfaces to be “post-selected” in the scriptable hydrostatics command.

Bug Fixes:

- Fixed a potential bug in Orca3D CSV exports (hydrostatics, planing analysis, displacement analysis, material library, sectional area curve) as well as in curve export formats (IDF, ORC, Pias) that could occur with non-US language settings.
- Fixed a formatting issue in hydrostatics report when many objects are included in the computation.
- Modified scriptable version of planing analysis command to allow input of negative shaft angle.
- Fixed a bug in the planing analysis form related to the positive sense of the shaft angle when selecting shaft angle interactively via the “Place” button.
- Modified hydrostatics analysis form behavior so that the weight calculator is always available, even with a Level 1 license.

Work-In-Progress Release 1.3 (May 2012)

Please note that this release requires Rhino version 4 service release 9 or later.

New Features:

- **Longitudinal Strength** - a new command, OrcaLongitudinalStrength, was added. This command, which is still

under development, is intended to allow Orca3D users to perform a longitudinal strength analysis using the hydrostatics and weight/cost capabilities built into Orca3D.

- **FastShip File Import** – a new capability was added to allow import of FastShip files. Now when you open, import, or insert files in Rhino, FastShip (.pex, .srf) files will be included in the file type filter. Note that surface trimming information is currently not imported.

Enhanced Features:

- **Hydrostatics**
 - Modified hydrostatics CSV output to include separate condition number and condition name where the number is used as reference in the section and righting arm output. Modified the default condition names to be "Condition x" instead of "Load Case x."

Bug Fixes:

- Fixed a bug in hydrostatics CSV output in which the condition number index was not being incremented for sectional output.
- Fixed a bug in Moment To Trim and Weight To Immerse calculations in which the check of the current unit system was not being performed properly.
- Fixed a bug in stability criteria evaluation in which commas as the decimal delimiter (non-US keyboard settings) could cause a problem. Also fixed a bug in the Stability Criteria Evaluation form related to list order.

Release 1.2.3 (February 2012)

Please note that this release requires Rhino version 4 service release 9 or later.

Enhanced Features:

- **Hull Design**
 - Modified OrcaWrapCorner command to be more intuitive. Corners are shown numerically in the display and the effect of selecting a corner to wrap is shown dynamically before the command completes.
- **Licensing:** Migrated the Orca3D network license handling to a newer version of the third party licensing libraries.

Bug Fixes:

- Corrected licensing error messages
- Fixed scriptable command, OrcaCreatePlaningHull, to use the same default parameter values as the interactive hull assistant.
- Fixed OrcaInsertNet, OrcaInsertChine, OrcaRemoveNet, and OrcaWrapCorner commands to exclude selection of polysurfaces as well as to allow modifying the viewport display mode while the command is active.
- Modified Orca3D output reports (from hydrostatics analysis, resistance analysis, and weight/cost analysis) to use a long date time format for "Report Time" to avoid potential confusion.
- Fixed OrcaCreateLinesDrawing command to properly place diagonals on opposite side of waterlines for all orientations.

Work-In-Progress Release 1.2.2 (January 2012)

Please note that this release requires Rhino version 4 service release 9 or later.

New Features:

- **Licensing:** Migrated the Orca3D standalone license handling to a newer version of the third party licensing libraries. In addition to improved robustness, the new licensing libraries now support self-service activation through a user website for cases where Internet activation is not possible (because the computer where Orca3D is installed is not on the Internet or due to firewall restrictions). See latest Help file for details.

Enhanced Features:

- **Hull Design**
 - Modified the OrcaCreatePlate dialog box to allow the user to preview the control net (in addition to previewing surface isoparameters). Also fixed a bug in this form when preview was selected that caused TAB key to tab to the Rhino command line instead of next field in the dialog.
 - Improved performance of Orca section calculation when dragging many objects.
- **Weight/Cost**
 - Added logic to the Weight/Cost Manager dialog so that if the user attempts to edit a weight/cost property associated with a block instance, a message is provided that only the weight/cost properties associated with the block definition can be edited (if other non-block instance objects were selected they are given

the option of editing them).

- **Hydrostatics and Stability**

- Modified Orca3D Properties to include an option requiring that “Pre-float” checks be made to ensure validity of the model prior to computing hydrostatics. This option is turned on by default so that new users will be required to consider using Pre-float to review their models at least one time. However the option can easily be disabled by a single mouse click for experienced users.
- Made minor formatting changes to hydrostatics output. Changed “Displacement” to “Displacement Weight” to clarify output.
- Modified real-time hydrostatics and sectional area curve behavior so that hydrostatics and SAC respond to whole object manipulations (in addition to surface control point manipulations). Note that response to whole object manipulations only occurs when the object placement is complete, not while it is being dragged.

- **Resistance and Powering**

- Modified the location of the legends in the resistance and powering reports to make them less likely to overlap with the plotted data.

- **Installation**

- Made minor modifications to network installation instructions to improve clarity. Added the network license installation instructions to the network server distribution and added programs menu shortcuts for instructions, release notes and the network license manager.

Bug Fixes:

- Units Fixes – Fixed bug in unit conversion values for metric mass density units other than kg/m^3 .
- OrcaMove Fixes - Fixed OrcaMove ghosting and an incorrect real-time sectional area curve behavior, in which one move caused two sectional area curve updates.
- Hull Assistant Fixes – Fixed a bug in previewing control nets for hull assistants in which the control net would sometimes be clipped from the view.
- PIAS Export Fixes - Modified PIAS section export to meet the requirement of positive transverse coordinate (regardless of whether port/stbd is modeled). Added logic to join station segments by filling in gaps with straight line segments.
- OrcaWrapCorner Fixes – Fixed a bug in OrcaWrapCorner command in which surface normals were reversed in certain cases.
- Hydrostatics Fixes - Fixed a bug in the scriptable version of the

OrcaHydrostatics command when using the “TransformModel” command option. Fixed a bug in which “undo-ing” a surface manipulation while real-time hydrostatics/sectional area curve were active did not cause a hydrostatics/sectional area curve update.

- Planing Analysis Fixes – Fixed a bug in Planing Analysis dialog box when interactively selecting shaft angle in which negative shaft angles were not recognized.

Work-In-Progress Release 1.2.1 (November 2011)

Please note that this release requires Rhino version 4 service release 9 or later.

New Features:

- **OrcaStraightenPoints:** Added a new command to place control points (or point objects) in a straight line in 3D, or in the 2D projection of a line.

Enhanced Features:

- **Hull Design**
 - **Lines Drawing:** Sections in the lines drawing are put on layers that mimic the Orca3D section layers in the model.

Bug Fixes:

- Lines Drawing Fixes - Addressed issue with diagonals being offset when the full hull was sectioned, addressed issue with scaling when the full hull was sectioned, all lines are now drawn on the same plane.
- Stability Criteria Fixes – Calculation of Hybrid Ratio corrected, calculation of areas under curves corrected, corrected calculation of heavy lifting and icing heeling arms.
- Resistance Prediction Fixes – Added total propulsive power output (PpTotal) to CSV export of planing hull and displacement hull analyses.
- Real-time Editing Fixes – Fixed a bug in which real-time hydrostatics did not update when moving control points via the OrcaMove control bar. Fixed a bug in which display of dynamic sections while editing control points was one mouse move behind in the active viewport.
- Lightweight Extrusion Objects – Fixed a bug in copying weight/cost data when copying lightweight extrusion objects in Rhino 5.

Work-in-Progress Release 1.2.0 (October 2011)

Please note that this release requires Rhino version 4 service release 9 or later.

New Features:

- **Native 64-bit Compatibility:** Developed a native 64-bit version of Orca3D targeted for the 64-bit version of Rhino 5. Note that due to an incompatibility issue between Orca3D and T-Splines (64-bit version only) real-time update of Orca3D sections when manipulating T-Splines objects has been temporarily disabled. It is anticipated that this issue will be addressed in the next release of T-Splines.
- **OrcaStabilityCriteria:** Added a new command, OrcaStabilityCriteria, which facilitates stability criteria evaluation. The command assumes that an Orca3D design condition has been defined and applies the evaluation to that condition. See the Orca3D Help File for more information.
- **Network Licensing:** Orca3D now supports floating network licenses. This allows licenses to reside on a network server and be passed out to client users in the network as needed. See the Orca3D Help File for additional information.
- **Real-time Sectional Area Curve:** Added a real-time sectional area curve capability. This capability is accessed in the Orca3D Design Hydrostatics command and form along with the option to define reference sectional area curve values. The real-time sectional area curve is displayed in its own dockable window using a custom control which allows a range of functionality including zooming, panning, image capture as well as export to a CSV file of the current and reference SAC values. The reference values can be defined individually in a grid, can be imported from a CSV file, or can be initialized from the current station locations.
- **OrcaInsertNet:** A new command, OrcaInsertNet, was created for adding surface control net rows/columns while attempting to maintain the surface continuity and uniformity. This command is an alternative to the standard Rhino command for inserting control points which removes surface discontinuities.
- **OrcaRemoveNet:** A new command, OrcaRemoveNet, was created for removing surface control net rows/columns while attempting to maintain the surface continuity and uniformity. This command is an alternative to the standard Rhino command for removing control points which removes surface discontinuities.

- **RIB Assistant:** A new hull assistant, RIB Assistant, was added to the OrcaHullAssistant command for the creation of Rigid Hull Inflatable Boats (RIBs). The assistant defines a simple planing hull with an inflatable tube attached at the gunwale. The resultant surfaces are trimmed and joined appropriately for ease of manipulation and hydrostatic analysis.
- **ORC Offset File:** Added an initial implementation of offset file (.off) export compatible with the ORC (Offshore Racing Congress) requirements (see <http://www.orc.org>). The capability can be accessed through the OrcaExportCurves command. Offset files generated from this implementation will generally require some further editing but should address the most time-consuming parts of creating the files.
- **OrcaManageWeightCost:** Added the ability to enable or disable individual weight/cost items in the Weight/Cost manager. The user can enable/disable selected items, enable all items, disable hidden items, or select Rhino objects to enable. Disabled items are not included in the weight/cg calculations for the design stability condition or general stability calculations when clicking the compute weight/cg button. For weight/cost reports, a new report option was added to report enabled items only.
- **Pre-Float:** Added a "Pre-Float" check to Orca3D hydrostatics that allows basic validation of input to the hydrostatics including checks for 1) CG within bounds of selected surfaces 2) no surfaces with negative displacement 3) consistency of sections and selected surfaces. Included a "Flip" option to automatically flip surfaces that have negative displacement or to allow them to remain selected for user review. If block instances are encountered they are not flipped but the user is notified.
- **Custom Reporting:** Added a custom reporting capability for Orca3D output of hydrostatics and stability, planing hull resistance analysis, displacement hull resistance analysis, and weight and cost reporting. See the Orca3D Help File for details on this capability.

Enhanced Features:

- **Hull Design**
 - **Hull Assistants:** Modified hull assistants to allow user to define custom sections or use default sections when displaying the current hull. Added defined stations (custom or default) to the hydrostatics computation so section-based properties are available. Orca3D sections will be created from the hull assistants if Preview Sections is turned on when the hull is created.
 - **Hull Assistants:** Modified the hull assistant forms for improved

functionality and ease of use. Added slider controls to allow dynamic manipulation of dimensional parameters. Added ability to display surface control nets. Made hull assistant surface display mode match the viewport display mode. Added front and back face color for interactive display of hull assistant geometry to the Orca3D properties.

- **Hull Assistants:** Added object names to surfaces created by Orca3D hull assistants.
- **Planing Hull Assistant:** Added default draft override and mid-deadrise override options on the Planing Hull Assistant. Changed parameter values for default planing hull.
- **Lines Drawing:** Added labeling of diagonals.
- **Curve Export:** Made OrcaExportCurves command scriptable. Modified PIAS export to mark knuckles in the output and to use Orca model orientation to write section curves from stern to bow and keel to deck.
- **Hydrostatics and Stability**
 - **Blocks:** Added the ability to compute hydrostatics for block instances containing surfaces, polysurfaces, and meshes.
 - **Sectional Area Curve:** Added drawing of sectional area curve in the Rhino model when Insert Flotation Plane option is selected in hydrostatics. Added section area curve color and scale factor to Orca3D properties.
 - **Weight Calculator:** Added persistence of weight items entered in the Orca3D weight calculator in the Rhino model file. Previously any items entered in the calculator were temporary in that closing Rhino would cause that data to be cleared.
 - **Output:** Added option to allow user to choose parameter to sort output results on for hydrostatics calculations with multiple load conditions. Modified hydrostatics report output to include up direction and forward direction on details pages.
- **Resistance and Powering**
 - **Resistance Analysis:** Added optional CSV output of drag analysis (Holtrop and Savitsky) results to both interactive and scriptable versions of the resistance analysis commands (in latter case if chosen it replaces ReportViewer output). This facilitates scripted access to resistance results.
 - Combined individual buttons for specifying propeller location in planing hull analysis into a single button.
- **Weight/Cost**
 - **Blocks:** Added the ability for blocks to contain weight/cost information. Weight/cost data that is assigned to Rhino objects used to define the block will cascade up to the block instances.

- **Import/Insert:** Added the ability to merge weight/cost information into the current model when importing or inserting a Rhino file.
- **Stock Material Library:** Added the ability to export/import a comma-separated-variable (CSV) file for the Orca3D stock material library. The functionality is accessed through the OrcaMergeStockMaterialLibrary and OrcaExportStockMaterialLibrary commands by selecting "CSV" as the file type. When importing materials, an attempt is made to compare the imported materials with existing materials (either by unique identifier or by name which is not unique) and allow the user to determine if existing materials are to be replaced or new materials are to be added.
- **OrcaReportWeightAndCost:** Extended the command for creating weight/cost reports to allow object grouping. A new form was incorporated to allow the user to select reporting and grouping options which include no grouping (the default behavior), grouping by Rhino layer, and grouping by Rhino object group.
- **OrcaCreateWeightCostPoint:** Modified the command, OrcaCreateWeightCostPoint, and the associated form to allow the user to specify a point material to assign to the point instead of using no material.
- **Negative Weights:** Allow the user to enter negative weight and cost values, but issue a warning.
- **CG for Points:** Modified the form for assigning stock materials so that if a point object is selected you cannot assign CG location (it must be the same as the point location). Any other objects can have the CG location assigned even if a point material is selected.
- **Miscellaneous**
 - **Rhino 5:** Modified Orca3D to accommodate the new Rhino 5 lightweight extrusion objects in weight/cost and hydrostatics functionality.
 - **OrcaViewPorts:** Modified behavior of OrcaViewports to not save current layout or restore; now a separate command OrcaLayout handles caching and restoring of a single layout during current rhino session; modified toolbar to have OrcaViewports/4View on one button and OrcaLayout Cache/Restore on a new button
 - **Toolbar additions:** Added Lasso Points to Rhino toolbar distributed with Orca3D.

Bug Fixes:

- Modified Orca3D as well as deployment projects to use ReportViewer 2010 to fix bug related to displaying points of interest in a rollover analysis; this also requires distribution of a later .NET framework (currently .Net 3.5 SP1); this required modifying PointOfInterest to expose World/Body location as individual double values and to modify the POI report definition files to use these
- Modified the command for assigning weight/cost properties to Rhino objects, OrcaAssignWeightCost, to behave properly in response to the Rhino Undo command. Unfortunately, it still does not respond properly to the Rhino Redo command due to a bug in Rhino 4 in which plug-in commands are not informed when a redo event occurs.
- Modified weight/cost behavior so that weight/cost properties cannot be assigned to Orca3D sections since they will be lost the next time the sections are recomputed.
- Fixed foil assistant errors with bulb size/location
- Fixed hull assistant display bug when linked viewports was turned on.
- Fixed bug in Planing Hull Assistant in which longitudinal distribution of deadrise was affected by model size and units.
- Fixed a units bug in calculation of Mt and Ml in hydrostatics; fixed a units bug in reporting of dimensional meshing parameters used for hydrostatics; fixed a units bug in reporting of points of interest location
- Changed calculation of Draft to be the minimum wet extent instead of the difference. Affects fully submerged models.
- Lines Drawing Fixes - TSplines and large hulls; Lines Drawing Form fixes; addressed issue with perimeter curves not showing up on certain models.
- Updated offset table plug-in to work without Orca plug-in being loaded; fixed a bug in offset table in which if Orca was not loaded, curve selection option was not correctly interpreted; also updated error message if no curves are found; modified offset table plug-in to create new worksheet in Excel workbook if needed for output.
- Modified the OrcaViewports command to leave Rhino page views unaffected; fixed bug in OrcaViewports command so that cplane positive axes will now always point fwd, stbd, and up for each view
- Added logic to the area calculation of the Section class to make it work in Rhino 4 and Rhino 5; they appeared to have changed the positive sense of the area between versions
- Fixed bug in OrcaWrapCorner command related to tolerances for coincident control points; fixed bug in OrcaWrapCorner for case where transverse direction is not the "y" axis direction.

- Fixed bug in scriptable version of OrcaHydrostatics for the case where righting arm calculation is enabled and load case is defined by sinkage, trim, and heel.
- Fixed bug in scriptable version of OrcaHoltropAnalysis command where the input minimum speed value was ignored. Fixed an orientation bug in Holtrop analysis in getting forward waterplane ending.
- Fixed bug in OrcaExportCurves command in which planar curves were being exported as 3D curves.

Release 1.1.0 (April 2010)

Please note that this release requires Rhino service release 6 or later.

New Features:

- **OrcaCreateFoil:** A new command was added for creating 3D foil shapes based on a 2D cross section. OrcaCreateFoil allows the user to choose a 2D foil section shape and specify the shape in planform including span, root and tip chord lengths, and trapezoidal or elliptical planform. Custom foil sections can be imported. A sample csv file is included to demonstrate how to import new foil offsets. The root and/or tip of the foil can be capped. A bulb body of revolution can optionally be added at the foil tip. This command also allows the user to analyze the volume, weight, and center of mass of the foil prior to creation.
- **OrcaCreatePlate:** A new command, OrcaCreatePlate, was added to create a flat Nurbs surface of specified degrees and number of control points. This command also allows the user to specify the location and orientation of the surface.
- **OrcaHullAssistant:** A new command, OrcaHullAssistant, has been added that lets the user create and manage hull shapes. This command replaces the previous Orca3D commands, OrcaCreateSailboat, OrcaCreateShipHull, OrcaCreatePlaningHull, although the scriptable versions of these commands remain in place for script use. OrcaHullAssistant allows the user to save specific combination of hull assistant settings in a library to be retrieved or modified for future use. Hull assistant settings can also be exported/imported to a file.
- **OrcaViewports:** A new command, OrcaViewports has been added that lets the user setup viewports in Bodyplan, Profile, Planview, and Perspective views, taking account of the user-specified model orientation in Orca3D Document Properties. Initial display settings

for the Orca3D viewports including grid lines display, grid axes, world axes icon, background gradient, control polygon culling, and bow direction can be set using the OrcaProperties command. OrcaViewports replaces the OrcaViewport macro in previous versions.

- **OrcaSelWeightCost:** A new command, OrcaSelWeightCost, allows users to select "normal" (e.g. unlocked and visible) Rhino objects that have or don't have (at the user's option) Orca3D weight/cost properties associated with them.
- **OrcaManageWeightCost:** A new command, OrcaManageWeightCost, allows the user to manage Orca3D weight/cost properties. This includes viewing current weight/cost properties including weight/cost totals, adding weight/cost points, and editing/deleting weight/cost properties.
- **OrcaProperties/Units:** The OrcaProperties command has been modified to allow the user to choose a currency unit label for cost input/output. Note that unlike other Orca3D units, there is no conversion factor associated with cost units. The command was also modified so that when a Custom unit system is chosen, the user can copy units from another non-custom system as a starting point. Also made default speed unit knots for all standard unit systems and the default power unit horsepower for imperial systems and kilowatts for SI systems
- **OrcaProperties:** OrcaProperties now allows the user to specify the forward and up directions for the current model. This removes the orientation restrictions on other Orca3D commands that required a particular model orientation. Note that specifying the model orientation via OrcaProperties does not transform your Rhino model in any way. It merely provides orientation information to Orca3D about the orientation of your model for use in other Orca3D commands (e.g. hydrostatics, drag analysis, lines drawing). If you wish to change the orientation of your model you need to use the native Rhino transformation commands (e.g. rotate).
- **Hydrostatics/weight integration:** Orca3D hydrostatics calculations have been integrated with weight properties. In the Orca3D command for defining the design hydrostatics condition (OrcaDefineDesignSimulation), the user now has the option to "Link to Orca3D Weight/Cost Items". This option, available only when defining the design condition with a weight/center, will automatically extract the weight and center of gravity from the total of all currently defined weight/cost properties. This link is "live" in the sense that changes/additions to weight/cost properties will be automatically reflected in the design condition. In the Orca3D

command for computing non-design hydrostatics (OrcaHydrostatics), the user now has the options to get the weight/CG from the currently defined weight/cost items or to use a simple weight/cg calculator to define the weight and center. These non-design options are static computations and thus are not automatically updated as weight/cost properties change.

- **OrcaHydrostatics:** Orca3D hydrostatics now allows the user to define virtually any combination of loading conditions in analysis using the "Custom Conditions" feature. In previous versions of Orca3D, the user could define many loading conditions for an analysis using the ellipsis syntax in the input fields. The resulting output would contain all combinations of the specified input values. Now the user can customize the collection of loading conditions to exclude or modify specific conditions. Further details on this functionality are provided in the Help file.
- **T-Splines Compatibility:** Orca3D has been made to be compatible with the T-Splines plug-in for Rhino (see <http://www.tsplines.com>). Orca3D sections can be cut through T-Splines objects and these sections will update dynamically as control points are edited. T-Splines objects can also be used for Orca3D hydrostatics analysis and can have Orca3D weight/cost properties assigned to them.

Enhanced Features:

- **User Interface:** Orca3D forms have increased error checking, logical tab orders, and improved resizing behaviors. The real-time hydrostatics form is now dockable and allows the user to choose the hydrostatics information to display. The lines drawing form has been modified to use a tabbed form due to the increased number of user options. The Orca3D toolbar behavior has been modified to allow the user to show names on the toolbar buttons. The Rhino model/filename has been added to the hydrostatics, powering, and weight/cost reports.
- **Orca Meshing:** Changed default Orca3D meshing parameters (used for hydrostatics and other Orca3D calculations) to obtain a more precise mesh at a cost of a slightly slower computational speed. The user can still set the Orca3D meshing parameters using OrcaProperties. Also changed the Orca3D Document Properties form to have new options for setting mesh parameters. These include "Orca3D Default", "Custom(Basic)", and "Custom(Advanced)". See the help documentation for a complete description.
- **OrcaHydrostatics:** Added the ability to use multiple ellipses in lists (eg. 1,2,...30,35...90). Added "Weight to Immerse" and "Moment to Trim" values to the hydrostatics condition detailed output, and

added GM_T and GM_L to the hydrostatics condition summary. Modified the station data plot so that immersed area and immersed girth are plotted to a similar scale by using exponential notation. Added list of Rhino objects selected for hydrostatics calculation to hydrostatics output. Users who want to script the OrcaHydrostatics command can now retrieve the resulting hydrostatics values from their script. A sample script demonstrating how to do so is included in the distribution. CSV file hydrostatics output is now an option for both the interactive and scriptable versions of the OrcaHydrostatics command. This provides users with a format they can use to customize their hydrostatics output and also provides a way to write scripts that analyze the hydrostatics output. Added non-dimensional longitudinal locations of center of buoyancy and center of flotation as measured from the aft end of the waterline (measurements from forward waterline ending are already included). Added decimal places to some of the hydrostatics output which is especially useful for smaller models. Improved readability of the computed sectional area curve by removing wetted girth from the plot.

- **OrcaDefineDesignSimulation:** If a design hydrostatics condition has already been defined in Orca3D, then the OrcaDefineDesignSimulation command will display the current design condition. Modified "real-time hydrostatics" behavior to make real-time hydrostatics window open immediately after the OrcaDefineDesignSimulation command is complete. Real-time hydrostatics window stays visible now even when the Rhino application is deactivated.
- **OrcaAssignWeightCost:** Users can now assign Orca3D weight/cost properties to Rhino mesh objects. Also, the form for assigning weight/cost to a Rhino geometry object has been modified to allow the user to filter the types of materials to choose from and to show the name of the Rhino object (when a single object is selected).
- **OrcaReportWeightAndCost:** Modified the weight/cost report to use separate pages for weight and cost and to add a column for the dimensional basis used for computing weight/cost, i.e. the length, area, or volume associated with the Rhino object (N/A is reported if all weight or cost values were directly assigned). For the stock materials page of the report, if a material is not in the user's material library it is denoted by prepending "local" to the material name. Also modified the OrcaReportWeightAndCost command to have a command argument indicating what Rhino objects to include in report (all objects, visible objects, selected objects).
- **Orca3D Drag Prediction:** The Orca3D drag prediction library, provided by HydroComp, Inc. has been updated. The new version

has improved error checking and allows non-integer speed increments for both Holtrop and Savitsky analyses.

- **OrcaCreateLinesDrawing:** Enhancements to the Orca3D lines drawing functionality include: the user is now able to specify which lines to include in the lines plan (Orca3D sections, all curves, selected curves), specify if x,y,z axes are shown in all three views, and specify the longitudinal location at which to split between fore and aft sides of the bodyplan view (stations and perimeter curves). This command now shows the maximum scale that will fit on the sheet size, and allows the user to adjust the text size for the labels. Diagonals, cants, and inclines are projected to their own plane in the lines drawing. Internal surface chines (defined by multiple surface knots) are now drawn in the lines drawing.
- **OrcaSections:** Modified Orca3D sections behavior so that if a section has a curvature graph turned on, it retains that setting after surface control points are moved and placed. Modified behavior of form for defining Orca3D sections to better handle issues related to negative section spacing values.
- **OrcaPointsOn:** Orca3D control points now draw net rows/columns corresponding to multiple knots in the surface in a user-specified color. This color is specified using the OrcaProperties command and is referred to as the "Chine Color".
- **Planing Hull Assistant:** Changed the default interactive behavior of the planing hull assistant so that the "mid-deadrise" angle is linked to the transom deadrise angle by default. This gives more usable hull shapes when modifying transom deadrise. The user can adjust the mid-deadrise angle independently if desired by clicking the associated checkbox.
- **Ship Hull Assistant:** The Orca3D ship hull assistant has been vastly improved to allow much better control of the hull shape, especially in the forebody. The user can also independently control side slope and deadrise angles, the flare curvature of the hull sides, the stem profile curvature, the forefoot shape, and the bow rounding. See the Orca3D Help file for complete details.
- **Sailboat Hull Assistant:** The sailboat assistant has been improved to allow independent control of hull flare and deadrise angles.
- **Orca3D Hull Assistants:** All of the hull assistants were improved to show section preview in a different color from the hull wireframe preview. Currently the section preview color is the same as that specified in the Orca3D properties for the "Chine Color".
- **OrcaWrapCorner:** Modified the command behavior so that Rhino viewports are not fit to extents after command completion.
- **OrcaInsertChine:** Modified the command to permit object snapping

when selecting the chine insertion point. If intersection snapping is enabled, the chine can be inserted at selected iso-parametric mesh lines by selecting near u-v mesh line intersections. Also fixed a bug in which pressing <ESC> during point selection still inserted the chine.

Bug Fixes:

- **Sailboat Hull Assistant:** Now allows negative transom heights (i.e. transom immersion).
- **Planing Hull Assistant:** Fixed a bug when setting transom deadrise angle to zero in which a non-zero chine width was not properly accounted for.
- **Hull Assistants:** Fixed a bug in the preview hydrostatics for the Orca3D hull assistants.
- **OrcaCreateLinesDrawing:** Fixed a bug that caused a crash if no printers were installed. Fixed the format of A-sized sheets to fully fit the lines on the paper. Fixed a bug in which the views were sometimes not properly located.
- **OrcaMove:** Fixed several bugs that caused crashes.
- **OrcaExport:** Fixed a bug in export of sections to PIAS format.
- **OrcaHydrostatics:** Fixed a bug in which running non-design hydrostatics after design hydrostatics were defined, could affect the defined design condition. Also fixed a bug in computing Ax and station of max area when there is parallel midbody and many sections are defined in the PMB. Fixed an intermittent bug in computing immersed girths in certain instances. Fixed a bug in the units label for righting moment. Fixed a bug in presentation of Mt and MI which is now measured from the resultant flotation plane. Modified computation of non-dimensional station of maximum area to be from the forward end of waterline instead of from the origin. The dimensional location is still measured from the origin. Fixed a bug in serialization of fluid density. Improved the overall stability and robustness of the Orca3D hydrostatics calculation engine.
- **OrcaAssignWeightCost:** Fixed a bug that caused a crash if a Rhino object is assigned a name containing a backslash ("\\"). Rhino point objects that have weight/cost properties assigned to them can only get their CG location from the point itself. You cannot assign the CG for a point object. Also fixed a units bug in the CG calculation for weight/cost points for units other than meters.
- **Orca Weight/Cost:** Fixed a bug in the Orca3D weight/cost calculation when objects with weight/cost properties were copied or mirrored. Also fixed a bug that occurred when Rhino objects with Orca weight/cost properties were joined or exploded.

- **OrcaPlaningAnalysis:** Modified section cutting/merging logic for complex geometries with holes, spray rails, tunnels, etc., to make the planing analysis more robust.
- **Orca Units:** Fixed a units conversion bug for moment values.
- **OrcaSections:** Fixed a bug in the preview of Orca3D sections for non-orthogonal sections (e.g. diagonals, cants, inclines).

Release 1.0.14 (November 7, 2008)

New Features:

- **OrcaInsertChine:** A new command was added to allow a user to insert a chine (i.e. slope discontinuity) into a surface along an iso-parameter. The command allows the user to choose the parametric direction, u or v.

Enhanced Features:

- **OrcaAssignWeightCost:** The form for assigning weight/cost to a Rhino geometry object has been modified to allow the user to create new materials by selecting "Add New Material(s)..." from the dropdown list.
- **OrcaAssignWeightCost:** The command now allows selection of more than one object at a time for assigning weight/cost properties. A "Clear" button was added to the form for assigning weight/cost properties to allow a user to remove weight/cost properties from selected objects.
- **OrcaReportWeightAndCost:** Added a progress bar during weight/cost report generation since calculations can be time consuming.
- **OrcaCreatePlaningHull:** The Planing Hull Assistant has been modified so that the resulting hull surface is degree 3 in both parametric directions. It had been degree 2 in one direction.
- **OrcaPlaningAnalysis, OrcaHoltropAnalysis:** The resistance analysis commands have been modified to allow the user to export the calculation to HydroComp NavCad and SwiftCraft files.
- **OrcaWrapCorner:** Added a check to see if the selected surface is trimmed. If so the user is notified that the command will remove trimming information and given the option to proceed or quit.
- **OrcaHydrostatics:** The OrcaHydrostatics command is now scriptable.

Bug Fixes:

- **Internationalization:** Made numerous changes to facilitate using Orca3D with international keyboard settings. In order to be consistent with Rhino, Orca3D requires all input using "." as the decimal separator and "," as the list separator.
- **Hydrostatics:** Fixed a unit conversion error in output of righting moment in lb-ft units.
- **OrcaCreateLinesDrawing:** Fixed a bug in display of block and prismatic coefficients when length and volume units are not consistent. Fixed a bug in display of wetted surface area value.
- **OrcaReportWeightAndCost:** Fixed a bug in which cost item output was sometimes denoted as having been set directly when it was computed from the associated geometry properties.

Release 1.0 (October 1, 2008)

- **Weight and Cost Module:** New functionality has been added for tracking weights and costs of geometric objects. A stock materials list facilitates rapid and consistent tracking of commonly used materials. Summary reports of weight and cost can be generated for the model.
- **OrcaMove:** Fixed a bug which did not allow control points from multiple surfaces to be moved, and improved the preview mode for more consistent operation when moving multiple types of objects simultaneously.
- **Report Format:** Adjusted the format to allow for a larger company logo. Extraneous blank pages were removed from the reports.
- **Planing Hull Assistant:** Fixed a bug which caused the chine height adjustment not to work.
- **Toolbar Settings:** Fixed a bug which prevented toolbar settings from being saved in Windows Vista.
- **Orca Sections:** No longer become selected when editing a surface.
- **OrcaHoltropAnalysis:** A new command, OrcaHoltropAnalysis, provides a method to compute the hull resistance and power of a displacement hull model. The command uses the HydroComp Drag Prediction Library and is based on the Holtrop method for computing resistance. A propulsive efficiency is entered by the user to compute propulsive power.

WIP Release 4.1 (September 2, 2008)

- **Units:** Fixed several issues related to units used in hydrostatics and speed/power calculations.
- **Orientation:** Fixed a bug in model orientation settings which occurred when reading in files saved in earlier WIP releases.
- **Formatting:** Modified the number format used in the section area and section girth hydrostatics output.

WIP Release 4 (August 29, 2008)

New Features:

- **OrcaOffsetTable:** A new command, OrcaOffsetTable, allows users to create traditional offset tables from a selected set of planar curves. When the command is run the user is prompted to include all curves, include Orca3D sections, or to select the curves to use for the offset table. The command opens Excel (must be installed on end-user machine for command to work) and generates the offset table output.
- **OrcaPlaningAnalysis:** A new command, OrcaPlaningAnalysis, provides a method to compute the hull resistance and power of a planing hull model. The command uses the HydroComp Drag Prediction Library and is based on the Savitsky method for computing resistance. A propulsive efficiency is entered by the user to compute propulsive power.
- **Licensing:** Added Orca menu item to start Orca3D License Manager as well as shortcuts to the Start menu. Also added current license status to Orca3D About box.

Enhanced Features:

- **OrcaCreateLinesDrawing:** Several enhancements were made to the Orca3D lines drawing functionality. Instead of having to specify the page size, dropdown lists of connected printers and available page sizes are presented. A custom paper size option is still offered. Portrait and landscape page orientation options have been added as have options to display/hide the title block, page border and section labels. Labeling of section curves is a new functionality. For station curve labeling, the user is provided the option to input station spacing and a station 0 location. The title block has been enhanced with more detail and available input. If the user has defined a "Design Hydrostatics Condition" an option to include principal characteristics on the drawing based on the hydrostatic properties at

the design condition is included. The body plan view now shows stations aft of amidships mirrored about centerline as in a traditional lines drawing. Lines drawing geometry is placed on a unique "Lines Drawing" layer incorporating date and time of creation. The drawing border, title block, and section labels are placed on their own sub-layers. Finally, if the user tries to create a lines drawing but has not defined any Orca sections, a warning message is issued.

- **OrcaCreatePlaningHull:** Modified the behavior of this command so that the hull is created as a single surface (in addition to the transom and deck). Previously the hull was created as a polysurface which meant it had to be exploded in order to perform control point editing.
- **Hull Assistants:** Improved user interface error handling to trap invalid input. Also changed "Stem" text occurrences to "Bow" to minimize confusion ("Stem" sometimes looks like "Stern" with certain fonts).
- **OrcaDesignHydrostatics:** Inform user if no design condition has been defined when attempting to compute design hydrostatics and provide option to define the design condition.
- **OrcaTheater:** Modified so that the theater page opens in a modeless form so that the user can continue to work in Rhino while the form is open.
- **OrcaSections:** Implemented the capability to import Orca section definitions from another 3dm file.
- **Persistence:** Improved robustness of logic to read and write Orca3D document data to 3dm files.
- **Help and Documentation:** Updated existing and created new Help Videos documenting the use of many of the Orca3D capabilities. Extended Orca3D Help documentation. Implemented context-sensitive help in Orca3D forms and added Orca commands to Rhino command help.

Bug Fixes:

- **OrcaCreatePlaningHull:** Fixed a bug in retrieving/applying Chine Height at Stem input parameter.
- **OrcaCreateSailboat:** Fixed a bug in sailboat hull assistant in which a manual change to the beam at transom text box did not cause an update when leaving the textbox.
- **OrcaHydrostatics:** Improved robustness for large heel angles and in handling ranges of input conditions. Modified the computation of LCB/Lwl and LCF/Lwl to be independent of longitudinal location of origin.
- **OrcaSections:** Fixed a bug in the definition of diagonals which had

been using the transverse coordinate instead of the vertical coordinate.

- **Hull Assistants:** Fixed a bug in the unit labels for dimension input which originated when converting Hull Assistants to modeless forms.
- **Orca Toolbar:** Changed the location of the Orca3D toolbar from the Orca installation folder to the "Common Application Data" folder. This was done to allow saving of changes to the toolbar location on Windows Vista where the standard user does not have permissions to write to the Orca installation folder. The location of the Command Application Data folder varies with operating system (typically "c:\documents and settings\all users\..." on Windows XP and "c:\program data\..." on Windows Vista).

WIP Release 3 (June 30, 2008)

New Features:

- **OrcaProperties:** Implemented the line type functionality for Orca3D control nets, set from the OrcaProperties command.
- **OrcaPointsOfInterest:** Implemented a new "Points of Interest" functionality in Orca3D. Points of Interest are defined via the OrcaPointsOfInterest command. They are used in any hydrostatics/stability calculation. The hydrostatics output reports the distance of the points of interest to the resultant waterplane. Points of Interest have an activation flag so they can be disabled/enabled at will. They are persisted with the 3DM file.
- **OrcaMove:** Implemented a new command, OrcaMove. This command allows the user to perform complex manipulations of geometry objects and Orca3D surface control points via a custom user control. This includes absolute or relative translations in either Cartesian or polar coordinates. Use of the up and down arrows permits the user to nudge the selected entities as needed.
- **Licensing:** Implemented a licensing mechanism within Orca3D. This mechanism will allow the end user to try out demo/evaluation versions, to purchase and activate a licensed version, to move a license from one machine to another, and to perform various other licensing operations.

Enhanced Features:

- **Hull Assistants:** Added session persistence to the Orca Hull Assistants so values entered will be remembered the next time that assistant is re-opened during the same session.

- **Hull Assistants:** Add content to Rhino document notes whenever a user creates a new hull via a Hull Assistant to indicate date of creation and parameters used.
- **Hull Assistants:** Implemented modeless forms for Orca3D hull assistants so that the user can modify the view while working with the assistant.
- **Hull Assistants:** Made the Orca3D Hull Assistant commands, OrcaCreateSailboat, OrcaCreatePlaningHull, OrcaCreateShipHull scriptable.
- **General User Interface:** Made numerous text, format, and behavioral changes to enhance the user experience.
- **OrcaExportCurves:** Added a default part name for IDF export since some programs will not accept a blank part name.
- **OrcaHydrostatics:** Modified hydrostatics calculations so that stations are computed on the surfaces selected for hydrostatics, regardless of what surfaces have Orca3D sections defined. If there is a mismatch between surfaces selected for hydrostatics and the surfaces for which Orca3D sections are defined, a warning message is issued to the user.
- **OrcaHydrostatics:** Made hydrostatics more robust for unusual resultant flotation plane attitudes.
- **OrcaProperties:** The user can now specify a logo file to use in Orca3D hydrostatics output. If the logo file specified cannot be found, the default Orca3D logo is used.

Bug Fixes:

- **OrcaHydrostatics:** Only compute section properties for those sections with the "calculation" checkbox set during hydrostatics calculations.
- **OrcaHydrostatics:** Fixed a bug in computation of section properties for heeled models.
- **OrcaProperties:** Fixed a bug in the behavior of the Orca Properties form when switching water density.
- **Globalization:** Fixed a bug which prevented use of Orca3D on computers with non-US keyboard settings. All Orca3D input should use US keyboard settings (decimal separator is "." and list separator is ",") as in Rhino.

WIP Release 2 (May 1, 2008)

New Features:

- **OrcaHydrostatics:** Added an option to insert the resultant flotation plane in the hydrostatics command. Also added an option to alternatively transform the model so that $z=0$ represents the resultant flotation plane. When either of these options is selected, Orca3D places points representing CB and CF. It labels and groups these objects with their associated flotation plane in case multiple flotation planes are being computed.
- **Reports:** Hydrostatics reporting now uses the Microsoft ReportViewer control. This control makes for faster reporting and has a much smaller installation footprint; User formats are supported through the use of the MS Express Web Developer with the appropriate report designer add-in
- **OrcaSections:** A new command to refresh the Orca3D Sections has been added (OrcaSectionsRecompute). It is assigned to the right mouse button on the Sections icon.
- **Real-time Hydrostatics:** The ability to see real-time hydrostatics while editing a surface has been added. This is enabled via the Design Hydrostatics.
- **Export Formats:** IDF and PIAS formats can now be exported using the Orca Sections that have been defined.

Enhanced Features:

- **Installation:** The installation program now opens the user's default web browser to display the Orca Theater html page, so that installation is not interrupted. It also now works with a FireFox browser.
- **OrcaProperties:** The handling of SI, Imperial, and Custom units has been overhauled. A user can now choose from four pre-defined Orca3D Unit Preferences: SI-kg, SI-tonne, Imperial-lbs, Imperial-LT. Further, a user can now choose a *Custom* units scheme, which allows the selection of specific units for different categories, e.g. volume in foot^3 and area in inch^2 . The *Custom* settings are accessed via the *Show Units* button.
- **OrcaExportCurves:** Default file extensions are now added when exporting to IDF or PIAS file formats.
- **OrcaHydrostatics:** Through the use of report parameters, the project, company, and analysis info is shown on all hydrostatics report pages.
- **OrcaHydrostatics:** BM, GM, LCF, TCF, and VCG values have been added to the condition summary and the summary has been slightly restructured.
- **OrcaHydrostatics:** Added button to access Orca3D Properties from the hydrostatics form

- **OrcaHydrostatics:** Modified the behavior of the Hydrostatics input dialog so that if Model Sinkage is chosen, Model Heel and Model Trim are automatically selected and LCG,TCG are disabled; if Weight is chosen all options are available.
- **Orca3D Tree:** The Orca Tree now supports multiselect.
- **OrcaSections:** Orca Sections may no longer be deleted with Rhino's Delete command. They can only be deleted by removing them in the Orca Sections dialog. They also cannot be edited directly. You must make a copy if you want a curve that is editable.
- **OrcaSections:** Made all of the layers created for Orca Sections a child of the "Orca3D Sections" layer. Removed the option to put all sections on one layer; the default color of sections is by layer; right-clicking section(s) and setting color changes the color to By Object or lets user set it to ByLayer.
- **OrcaSections:** Orca Sections are now given names according to their type and location.
- **OrcaSections:** The Orca Sections tree now allows multiselect.
- **OrcaSections:** Behavior has been changed so that the Orca Sections are updated any time a surface is transformed or modified. Real-time (dynamic) updating still only occurs when editing Orca Control Points.
- **Real-time Sections:** When moving Orca control points with Sections updating in real-time, after each move the Sections would be selected. This has been corrected.

Bug Fixes:

- **General:** Various spelling errors have been fixed.
- **Orca3D Toolbar:** Issues regarding the visibility of the toolbar have been fixed.
- **Orca3D Tree:** Inserting control points into a surface while the Orca Tree was on caused an error. This has been fixed.
- **Orca3D Tree:** Fixed an error where the lightbulb indicator in the Orca Tree would be off for items that were just grouped.
- **Orca3D Tree:** Fixed a bug in the Orca Tree where a layer could remain highlighted in the tree after an object had been selected in the graphical window.
- **OrcaCreatePlaningHull:** Planing hull assistant did not allow flat sheer line. This is now allowed. Corrected in the Sailboat Assistant as well.
- **OrcaHydrostatics:** Stability calculations at 90 and 180 degrees are now correct.
- **OrcaHydrostatics:** Corrected waterplane inertia unit labels in hydrostatics output.

- **OrcaHydrostatics:** Fixed the reporting of section locations in the Hydrostatics output to reflect the current units.
- **OrcaHydrostatics:** Hydrostatics reports no longer include blank pages for section and righting arm data if that data is not available.
- **OrcaHydrostatics:** Corrected error in the reporting of TCF.
- **OrcaHydrostatics:** Corrected waterplane area calculation in English units.
- **OrcaProperties:** Removed zoom extents behavior after OK on OrcaProperties dialog.
- **OrcaSections:** Error caused when Preview was used in the Sections dialog before defining any sections has been fixed.
- **OrcaSections:** Corrected error that caused the section calculation checkbox to not remain unchecked.
- **OrcaSections:** The names of Orca Sections now update in the tree to reflect a change in units.
- **OrcaSections:** The options in the Orca Sections dialog are preserved for each Section type.
- **OrcaTree:** The Orca Tree was modified so that it no longer slows way down when large models are loaded.
- **Real-time Hydrostatics:** The units in real-time hydrostatics would not reflect the units of a model that was read in while the real-time hydros window was open. This has been fixed.
- **Real-time Sections:** Corrected error that when recomputing sections; locked sections and section layers did not get deleted when they should have been.
- **Real-time Sections:** Corrected a problem that caused the real-time section line types to not be correct.
- **Vista OS:** Fixed a bug that caused a crash when exiting in the Vista operating system.

WIP Release 1 (Feb 29, 2008)

The Work-In-Progress (WIP) is intended to begin the process of soliciting feedback from the user community. While every attempt is made to release stable code, it does not undergo as thorough a testing process as a commercial release. After receiving feedback, there may be major changes in functionality.

Part

IV

4 Introduction

The topics in this section provide some basic information about Orca3D, what it is for and what you can do with it.

How to get started

- Check out [Latest Updates](#)^[16] for details on the latest features.
- See [Getting help](#)^[73] for details on using this help and getting more information about Orca3D.
- Then work through the [Quick Start Tutorials](#)^[93] to familiarize yourself with using Orca3D.

4.1 About Orca3D

Orca3D makes designing any type of vessel a pleasure. All the tools you need are at your fingertips in a single intuitive environment. Instead of wasting countless hours moving your model from one program to another, you can focus all your energy on the creative aspects of your design, so that all your working time is productive time.

➔ If you want to get started with Orca3D right away go to the [Quick Start Tutorials](#)^[93].

Intuitive working environment

Orca3D runs as a plug-in to the Rhino program, so you don't need to learn another user interface and set of terminology. Is it an incredibly powerful 3D modeling system that includes true naval architectural tools, or a marine design program with amazing 3D modeling and rendering capabilities? Think of it either way, but the bottom line is that it will be easier to learn, more productive, and more fun!

Single program, without the need for file transfers

When your design process includes using multiple programs, an amazing amount of your day can be spent trying to accurately move your model from one program to another. This time is totally non-productive, and steals from the creative process. If you still need to import or export data, Rhino and Orca3D support a broad range of file formats, making the process as quick and painless as possible.

Easily cut stations, buttocks, waterlines, and other sections

through your model

Orca3D adds the capability to Rhino to easily define a table of stations, buttocks, waterlines, cant frames, inclines, and diagonals, and immediately see the curves on the surface(s). Watch the curves update in real time as you modify a surface, or choose to update them manually, with a single button click, after you have made a series of changes to your model.

Intact Hydrostatics & Stability

In order to design a meaningful hull, you must be able to compute the intact hydrostatics, to ensure that you are meeting the basic requirements for displacement and LCB, as well as the less obvious, but still important, objectives for block coefficient, prismatic coefficient, initial stability, and many other parameters. With Orca3D, a single button click will compute and display a complete table of intact hydrostatics and stability information, with output to the screen, as well as optionally to other formats such as Microsoft Excel® and Adobe Acrobat®.

➔ Orca3D uses the surface model to compute hydrostatics, and can handle complex models with arbitrary shapes. There are no limits to the types of shapes that can be analyzed; monohulls, multihulls, submersibles, drilling rigs, etc.

Create hull surfaces quickly with Hull Assistants

Hull design in Orca3D is done using NURBS surfaces (see the Rhino Help file for a complete discussion of NURBS surfaces). Usually the most difficult step in designing a hull with NURBS is creating the initial 3D shape; after you have that, modifying and fairing the shape is straightforward. To speed up this process, Orca3D contains a number of Hull Assistants that allow you to specify a number of basic parameters, and instantly create a 3D NURBS surface, which can then be modified and faired to reach your final hull shape. As you modify the parameters, you can see the hull shape change in real time, as well as seeing the influence on basic hydrostatics properties.

Fair hulls easily and produce lines drawings

Create, modify, and fair hull surfaces with Orca3D. Orca3D takes the mathematical power of Rhino's NURBS surfaces, and adds the tools necessary to create your hull shape, while analyzing it for fairness and hydrostatic properties. See the effects of your modifications in real time, analyze curvature, tweak curvature, and finally, produce a lines plan drawing, all the while working in the familiar and intuitive Rhino environment.

Predict the speed of your vessel

Using analysis libraries for either planing or displacement hulls, Orca3D can quickly predict the effective horsepower versus speed for your design.

Track the weight, center of gravity, and cost of your model

With Orca3D, you can assign weight and cost properties to every object in your model, and get a report summarizing the total weight, center of gravity, labor cost, and material cost. The property can be a specific value (e.g. 5 kg, \$350, etc.) or a density function (e.g. 2.8 lb/ft², €32/m², etc.). A library of standard materials can be created, and properties assigned simply by selecting an item from the library.

See also:

[Quick Start Tutorial](#) 

4.2 Why Orca3D?

Orca3D is quick, accurate, and written for naval architects by naval architects!



Save time

Orca3D helps you to create and analyze your model more quickly. The time required to create a basic hull, or compute intact stability, can be measured in just seconds.



Save money

By performing more of your work in one program, you can eliminate the time and cost associated with purchasing and maintaining separate programs.



Concentrate on your work

Because Orca3D runs inside Rhino, you don't need to learn a new program. The intuitive user interface is transparent and straightforward. You don't need to spend time transferring models to different programs for analysis; instead, you can concentrate on your design.



Designing should be fun and creative

You don't need to be bogged down with difficult and finicky file transfers, or need to be an expert in five different programs. Do it all in Rhino/Orca3D...

4.3 Getting help

Using this help file:

This help is designed to be used on-screen. It is extensively cross-linked so that you can find more relevant information to any subject from any location. If you prefer reading printed manuals a PDF version of the entire help is installed in the \Help subdirectory, located in the directory where you installed Orca3D (by default, C:\Program Files\DRS_ATC\Orca3D). This may be useful as a reference but you will probably find that the active hyperlinks, cross-references and active index make the on-screen electronic version of the help much more useful.

Getting started

Start by studying the [Introduction](#)^[70] and [Quick Start Tutorials](#)^[93] sections.


Using the help while you're working

As far as possible the help separates instructions and background information. This makes it much easier to refer to the "how-to" instructions when you are in a hurry and need to get your work done.

- **To learn about something** consult the Introduction topic in each section.
- **To learn how to do something** consult the following topics in each section.
- **When you're frustrated** use the Index and Search functions and check out the [Frequently Asked Questions](#)^[486] section.

All sections have extensive links to the other relevant sections so it doesn't really matter where you start.

Context-sensitive help:

- When appropriate, dialogs have a Help button () in the upper right corner that displays the relevant section of the online help.
- By enabling Rhino's Command Help feature, you can see Orca3D help appear automatically as you use the various functions. From Rhino's Help menu, select Command Help.

Tutorials:

- See [Quick Start Tutorials](#)^[93] in the help for some basic tutorials to get you started with using Orca3D.

Getting a printed user manual:

Please don't try to print the HTML Help version of the help from the Microsoft help viewer; it would look terrible. You will find a formatted PDF version of the entire documentation designed for printing in the \Help folder, or in the Support menu on our website:

 <http://www.orca3d.com/>

As mentioned above, however, you will probably find that the on-screen version of the help is much more useful because of the hyperlinks and cross-references.

See also:

[Online information and links](#) 

4.4 Online information and links

Orca3D Latest Orca3D News:

News about Orca3D is posted on our website, at:

 <https://orca3d.com/blog/>

Video Tutorials:

A range of video tutorials demonstrating the basics of using Orca3D:

 <https://orca3d.com/support/video-tutorials/>


Webinars:

Recorded live webinars demonstrating Orca3D:

 <http://www.orca3d.com/webinars>

Other news groups and forums:

Rhino resources:

 Rhino Support Newsgroup: <news://news.rhino3d.com/rhino>

 Rhino Web Support Newsgroup: <http://news2.mcneel.com/scripts/dnewsweb.exe?cmd=xover&group=rhino>

 Rhino Frequently Asked Questions: <http://www.rhino3d.com/faq.htm>

 Rhino Wiki: <http://www.rhino3d.com/wiki.htm>

 Rhino On-line Training: <http://www.rhino3d.tv/>

 Rhino News Blog: <http://blog.rhino3d.com/>

See also:

[Getting help](#) 

4.5 How to buy Orca3D

You can buy Orca3D from a local reseller, or directly online worldwide with all three major credit cards. As soon as your transaction is completed you will be able to download and install the program and start working right away.

Resellers

There are a number of Orca3D resellers around the world, who can provide you with support for both Orca3D and Rhino. Use the link below to find the reseller closest to you:

 <http://www.orca3d.com/resellers>

Direct order link:

 <https://orca3d.com/buy/>

Orca3D home page:

 <http://www.orca3d.com>

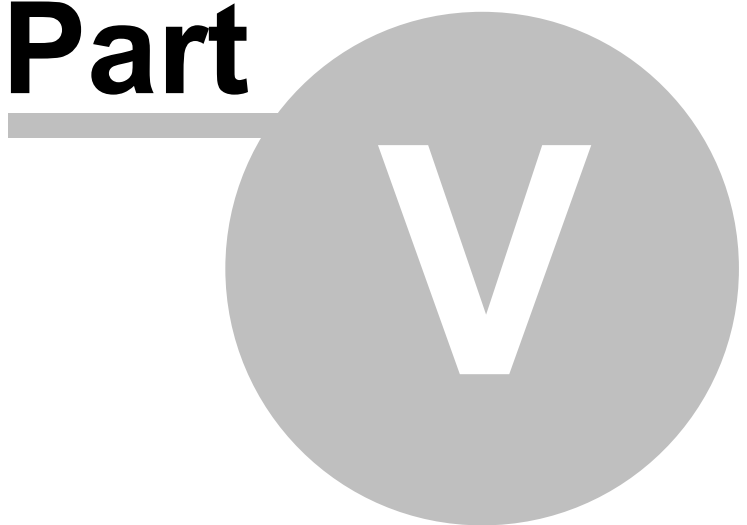
Email support:

 support@orca3d.com

Postal mail and phone:

821 Chesapeake Ave. #4695
Annapolis, MD 21403
Phone +1 (410) 696-3308
Sales: Ext. 0
Support: Ext. 1

Part




5 Properties & Units

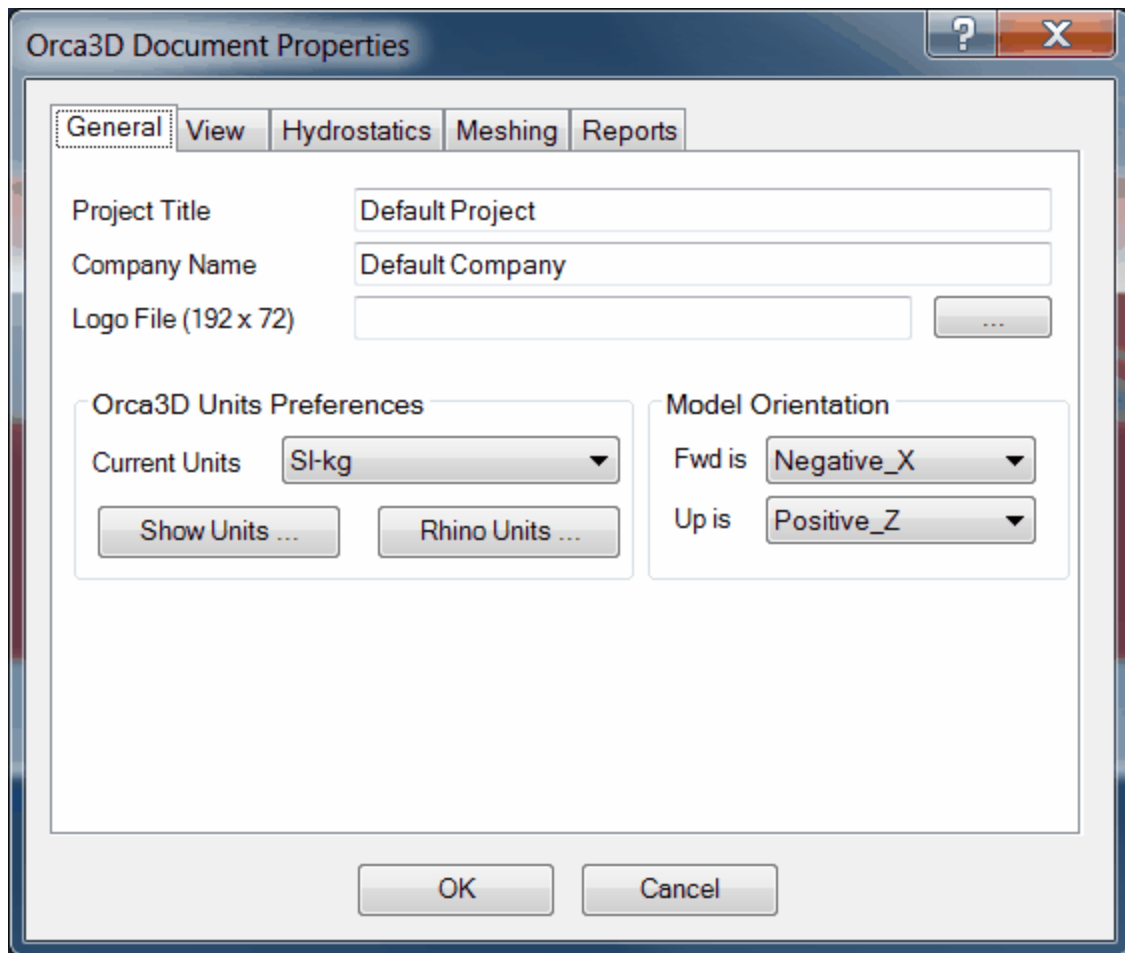
The Orca3D Document Properties is where Orca3D stores all of the properties that are available for you to manage.

In the Orca3D Document Properties you can edit several different items:

- Information about yourself and your project.
- Orca Units
- The orientation of the model.
- OrcaViewports and other view-related settings
- The properties of the water the model is supposed to be used in and other hydrostatics-related settings.
- Orca Mesh properties, and control polygon settings
- Location of Custom Report files

Toolbar	
Menu	Orca3D > Properties
Command	OrcaProperties

Start the command with the toolbar icon, menu selection or keyboard command. The Orca3D Document Properties Dialog Box will appear:



General Tab

Type the Project Title and Company Name that you wish Orca3D to use. These items are used in reports (hydrostatics, speed/power), and the lines drawing. They are stored with the model in the Rhino 3dm file.

The line titled "Logo File" is the filename and path of the logo file to be used in the reports. The file you wish to use must either be in bitmap or JPEG format, up to 192 x 72 pixels. You may type the path to the file into the text box, but a more convenient method is to click the button to the right labeled "..." and browse to the location of the logo file.

Orca3D Units Preferences

Select the unit system that you wish Orca3D to use.

- The Length unit is independent of Orca3D and is managed and maintained by Rhino. If you wish to change the Length unit, this must be done in Rhino's settings.
- The currency unit does not have a conversion factor from one currency to another.
- A note on tolerance: as with the Length unit, the tolerance value is part of Rhino's settings. Rhino's Help says the following about setting your tolerance:

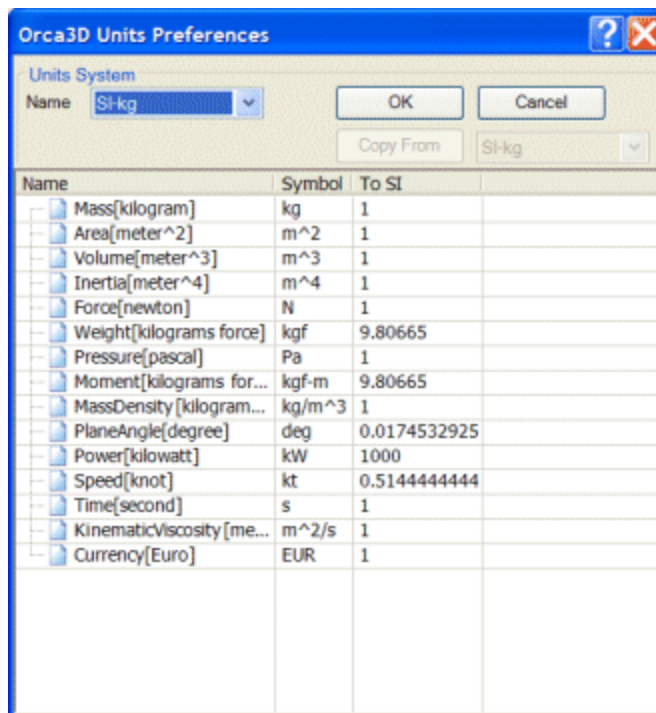
"In general, Rhino works best if you choose a unit system whose absolute tolerance

is around 0.01 to 0.001, the "size" of a small feature (like a tiny fillet or small curve offset distance) is $\geq 10 \times \text{tolerance}$, and the "size" of the model is ≤ 100000 .

Using an absolute tolerance that is smaller than 0.0001 will noticeably slow some intersection and fitting processes." (for complete information, see "Document Properties: Unit Settings in Rhino's Help guide")

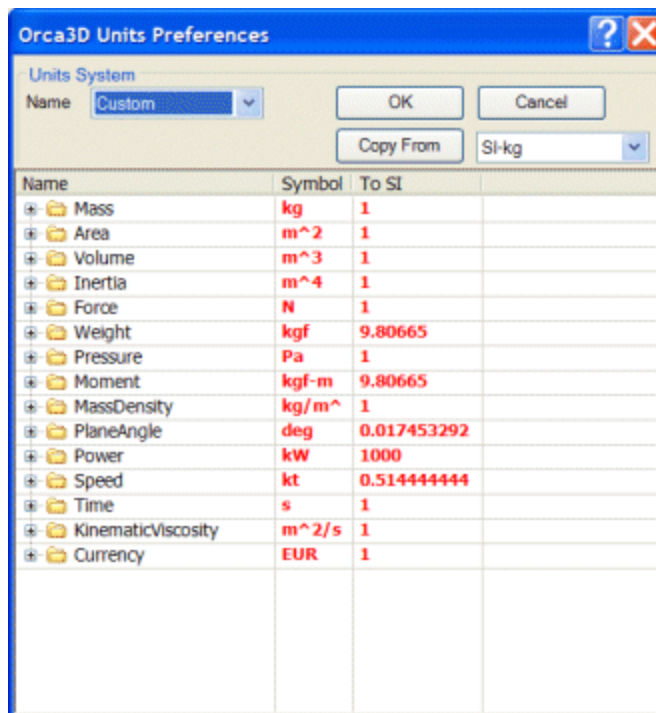
This implies that a typical vessel, designed in meters, could have the absolute tolerance set between 1 millimeter and 1 centimeter (0.001 to 0.01). If your model will have small features, such as fillets on the order of 1 centimeter in size, the tolerance should be closer to 0.001. If the vessel is designed in inches, a tolerance of 0.01 would be more reasonable. For a vessel designed in feet, perhaps 0.003 is appropriate.

Select the "Show Units ..." button to see a more detailed listing of the unit system. If you have any unit system besides custom selected, the a dialog similar to the following will appear:



You can select the different unit systems at the top and see which units are being used for each unit type. To the right of the unit is the abbreviation for the unit, and the conversion factor to SI units.

If you select Custom as the Unit System, the dialog box changes as follows:



Use the "Copy From" button to "initialize" your custom settings using one of the standard unit systems.

The change of the text color to red indicates that the properties are now available to be changed. If you select the plus icon next to any unit type, something similar to this will appear:

<div> <div></div> <div>Mass</div> </div>		kg	1
<input type="checkbox"/>	pound mass	lbm	0.45359237
<input type="checkbox"/>	slug	slug	14.593903
<input type="checkbox"/>	gram	g	0.001
<input checked="" type="checkbox"/>	kilogram	kg	1
<input type="checkbox"/>	tonne	t	1000

To select a different unit for this unit type simply check the box next to the unit. The abbreviations and conversion to SI are still viewable for your convenience. Customize each unit type at your discretion to fully customize the Unit System.

Select OK when finished editing the units.

Model Orientation

For various purposes, Orca3D must know which coordinate axis is longitudinal, which is transverse, and which is vertical, and further, what direction the positive sense of each of these corresponds to. For example, the definition of a "station" is a plane at a constant X value, if X is your longitudinal coordinate. And while the direction (positive X aft or forward) doesn't matter for hydrostatics calculations, it is important for speed/power analysis (the program needs to know which end is the bow). Orca3D defaults to a coordinate system with positive X aft, positive Y to starboard, and positive Z up. However, you can set the coordinates in any of 24 combinations, all of

which are right-hand rule coordinate systems.

- **Fwd is:** Select the coordinate direction that corresponds to the "Forward" direction in your model.
- **Up is:** Select the coordinate direction that corresponds to the "Up" direction in your model.

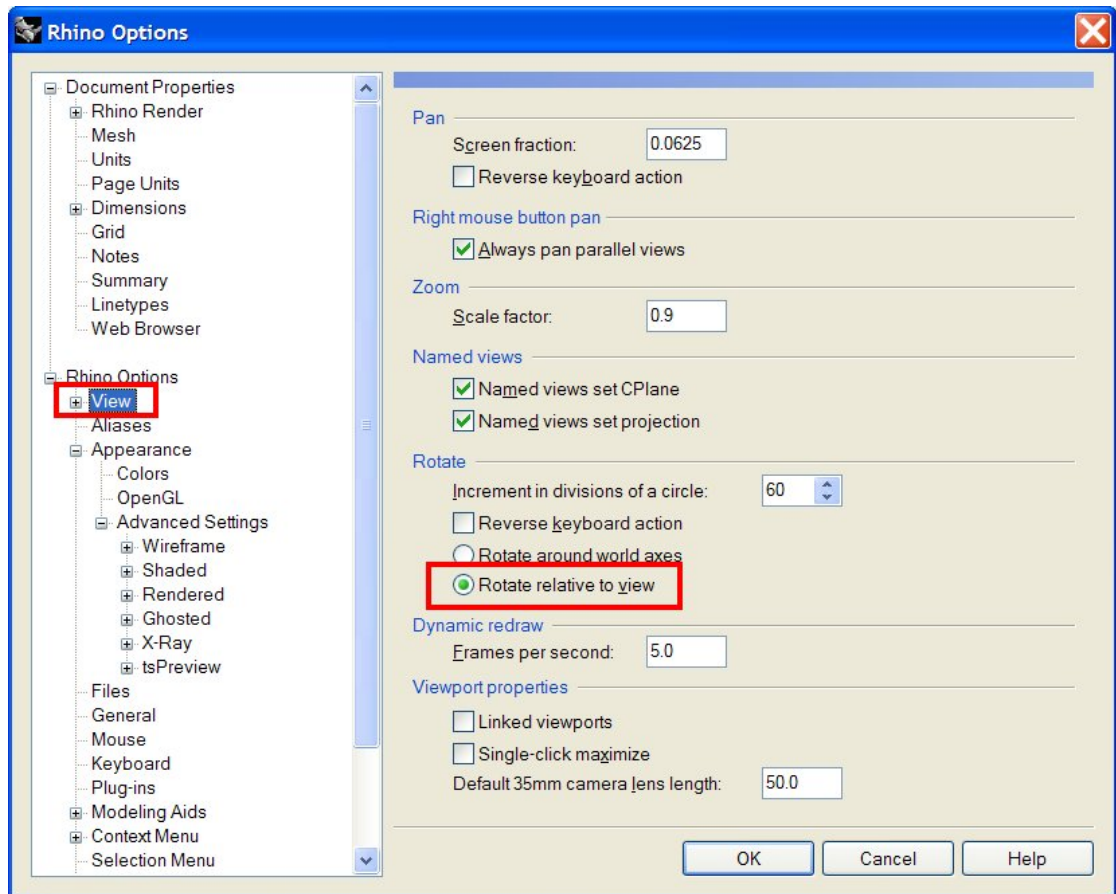
Note: *Changing these values will not rotate your model.* You must use the standard Rhino commands (Rotate or ScaleNU) to change the orientation of your model.

Orca3D always maintains a right-handed coordinate system. This implies the following:

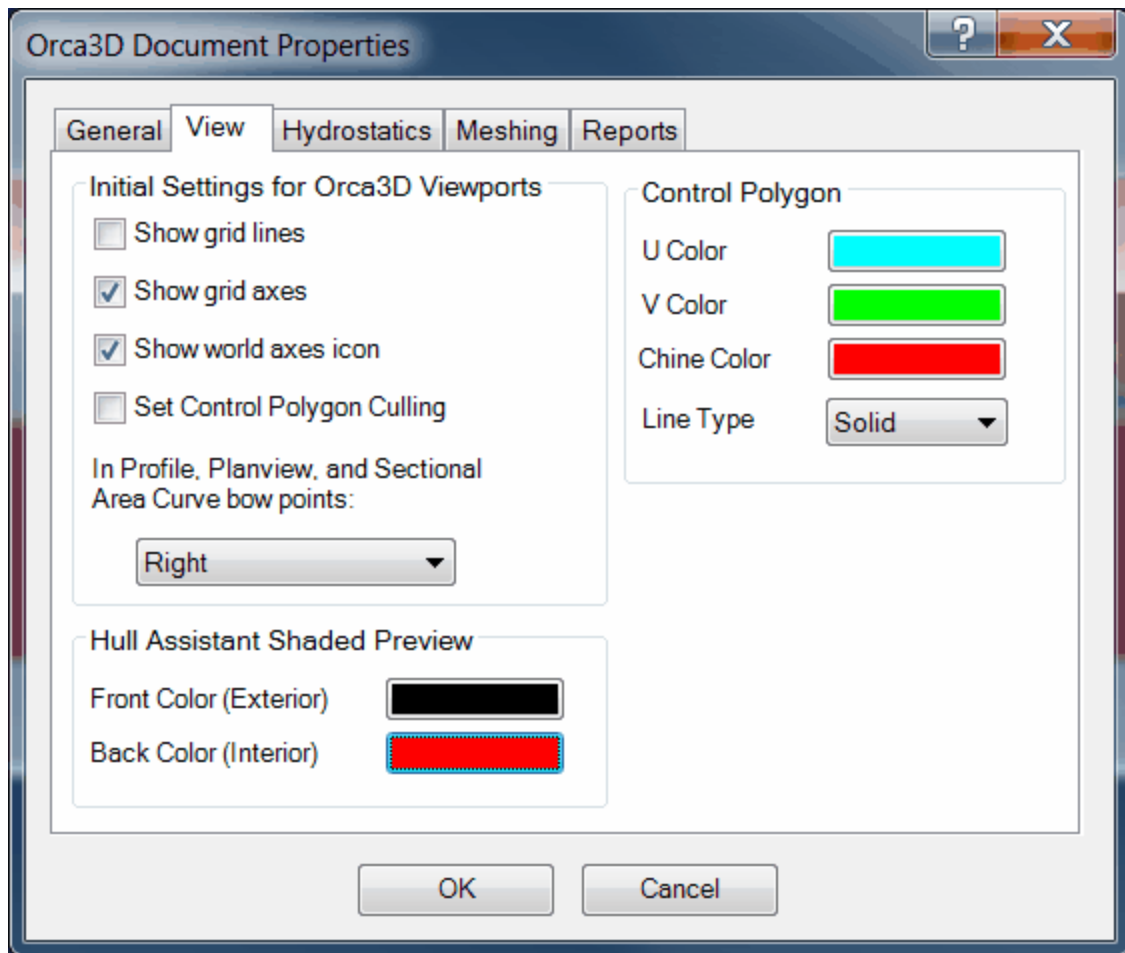
If Fwd is set to	...and Up is set to	...then Starboard is	...and positive Trim is	...and positive Heel is to
Positive X	Positive Z	Negative Y	Bow down	Starboard
Positive X	Negative Z	Positive Y	Stern down	Starboard
Positive X	Positive Y	Positive Z	Stern down	Starboard
Positive X	Negative Y	Negative Z	Bow down	Starboard
Negative X	Positive Z	Positive Y	Stern down	Port
Negative X	Negative Z	Negative Y	Bow down	Port
Negative X	Positive Y	Negative Z	Bow down	Port
Negative X	Negative Y	Positive Z	Stern down	Port
Positive Y	Positive Z	Positive X	Stern down	Starboard
Positive Y	Negative Z	Negative X	Bow down	Starboard
Positive Y	Positive X	Negative Z	Bow down	Starboard
Positive Y	Negative X	Positive Z	Stern down	Starboard
Negative Y	Positive Z	Negative X	Bow down	Port

Negative Y	Negative Z	Positive X	Stern down	Port
Negative Y	Positive X	Positive Z	Stern down	Port
Negative Y	Negative X	Negative Z	Bow down	Port
Positive Z	Positive X	Positive Y	Stern down	Starboard
Positive Z	Negative X	Negative Y	Bow down	Starboard
Positive Z	Positive Y	Negative X	Bow down	Starboard
Positive Z	Negative Y	Positive X	Stern down	Starboard
Negative Z	Positive X	Negative Y	Bow down	Port
Negative Z	Negative X	Positive Y	Stern down	Port
Negative Z	Positive Y	Positive X	Stern down	Port
Negative Z	Negative Y	Negative X	Bow down	Port

If you choose a coordinate system with the Up direction set to a Negative direction, you may find that rotating the view in the Perspective viewport is non-intuitive. This is because by default, Rhino does rotations about the World Coordinates. To make it more intuitive, open the Rhino Options dialog (Tools > Options, or right-click on a viewport name and select Display Options). Click on View, and then select "Rotate relative to view."



View Tab




Orca3D Viewport Settings

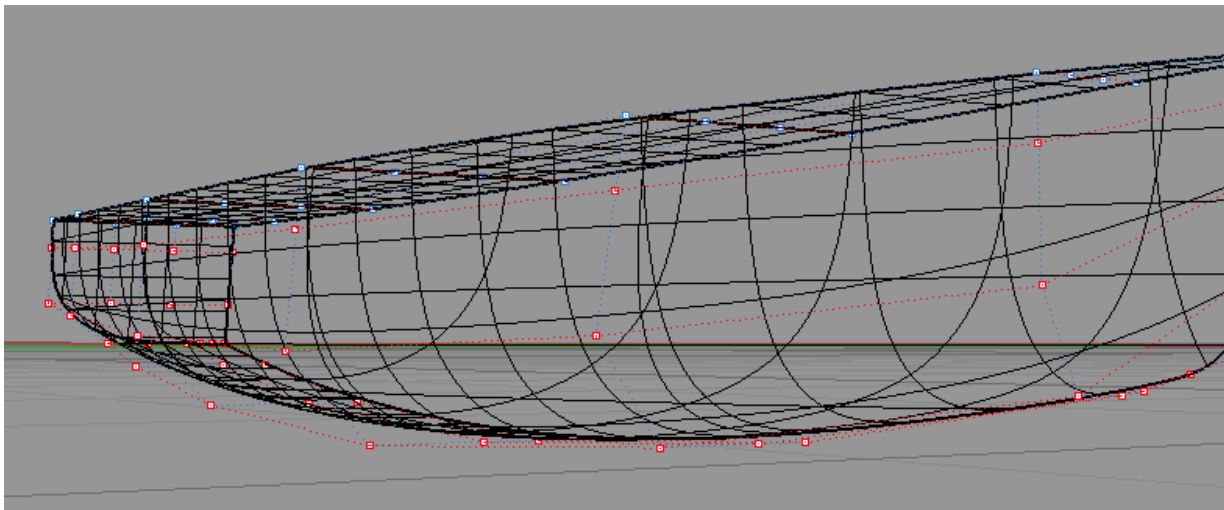
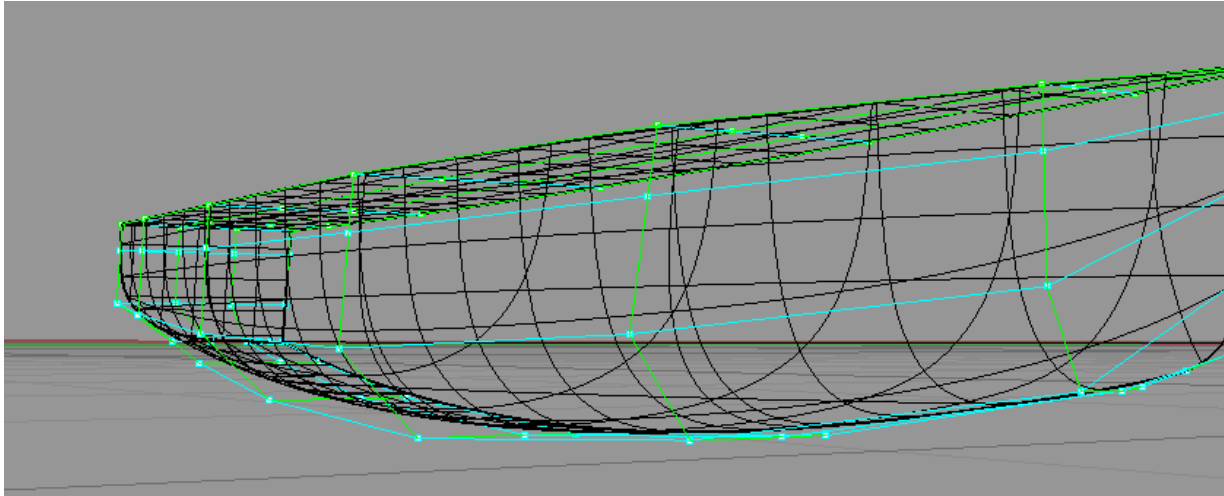
These settings allow you to change the appearance of Rhino whenever you change to [Orca3D Viewports](#)⁹⁶.

- Optionally shows or hides the grid, axes, and world axes icon.
- Toggle Control Polygon Culling: To "de-clutter" the view of the control net, only the control points on the side of the surface that face the camera are displayed.
- In Profile and Planview, bow points: Select "right" or "left," depending on your preference. This does not change the coordinate system, simply the camera position.

Control Polygon

Orca3D has its own [control polygon system](#)¹²¹, which is similar to the control points maintained inside Rhino. If these polygons are edited, the hull and sections (and optionally the hydrostatics) are updated in real time. The Control Polygon Section allows you to control their display color and line type so you can easily distinguish them from typical Rhino control points.

The Control Polygons can be turned on and off by either going to (Orca3D > Hull Design > Orca3D Control Points On) in the menu, typing *OrcaPointsOn* in the command line, or clicking the  icon in the Orca3D toolbar. Two example hulls with Control Polygons on are shown below:



On the hull, the U direction usually designates the longitudinal direction on the hull, and the V direction generally designates the direction from bottom to top on the hull.

Click the box to right of Polygon U color to select the color that you wish the U direction polygons and control points to be displayed in. Click the box to right of Polygon V color to select the color that you wish the V direction polygons and control points to be displayed in. Select whether you wish the polygons to be drawn with a solid line or a dotted line.

Rows in the net that correspond to chines that are created with the

[OrcaInsertChine](#)^[207] command (or by any means that create multiple knots equal to the degree of the surface) can be drawn in a different color. By default they are drawn in red.

Hull Assistant Shaded Preview

Here you can control the colors to be used in the [Hull Assistant](#)^[98] shaded preview. The Front color is the outside of the hull, while the Back color is the inside. To be consistent, you may want to consider using the same colors as you have defined using Rhino's backface coloring option, described [here](#)^[249]. It's important to know which side of a surface is the outside, as this must be the side touching the water in order to get correct hydrostatics results.

Hydrostatics Tab

The image shows the 'Orca3D Document Properties' dialog box with the 'Hydrostatics' tab selected. The dialog has a title bar with a question mark and a close button. Below the title bar are five tabs: 'General', 'View', 'Hydrostatics' (selected), 'Meshing', and 'Reports'. The 'Hydrostatics' tab contains three sections: 'Fluid Properties', 'Equilibrium Warning Thresholds', and 'Section Area Curve'. In the 'Fluid Properties' section, 'Fluid Type' is set to 'Seawater' in a dropdown menu, and 'Mass Density' is set to '1025.900' with units 'kg/m^3'. In the 'Equilibrium Warning Thresholds' section, 'Heel Threshold' is set to '45' degrees and 'Trim Threshold' is set to '10' degrees. In the 'Section Area Curve' section, 'Scale Factor' is set to '1' and 'Curve Color' is set to a bright green color. At the bottom of the dialog are 'OK' and 'Cancel' buttons.

Orca3D Document Properties		
General View Hydrostatics Meshing Reports		
Fluid Properties		
Fluid Type	Seawater	
Mass Density	1025.900	kg/m^3
Equilibrium Warning Thresholds		
Heel Threshold	45	degrees
Trim Threshold	10	degrees
Section Area Curve		
Scale Factor	1	
Curve Color	[Green]	
OK Cancel		

Fluid Properties

Select either Seawater, Freshwater, or custom from the drop down menu. Orca will use this fluid property to calculate the hydrostatics of your model.

- a. If you choose either seawater or freshwater, the density is displayed below the choice.
- b. If you choose custom, you must enter your desired density into the text box with the indicated units.

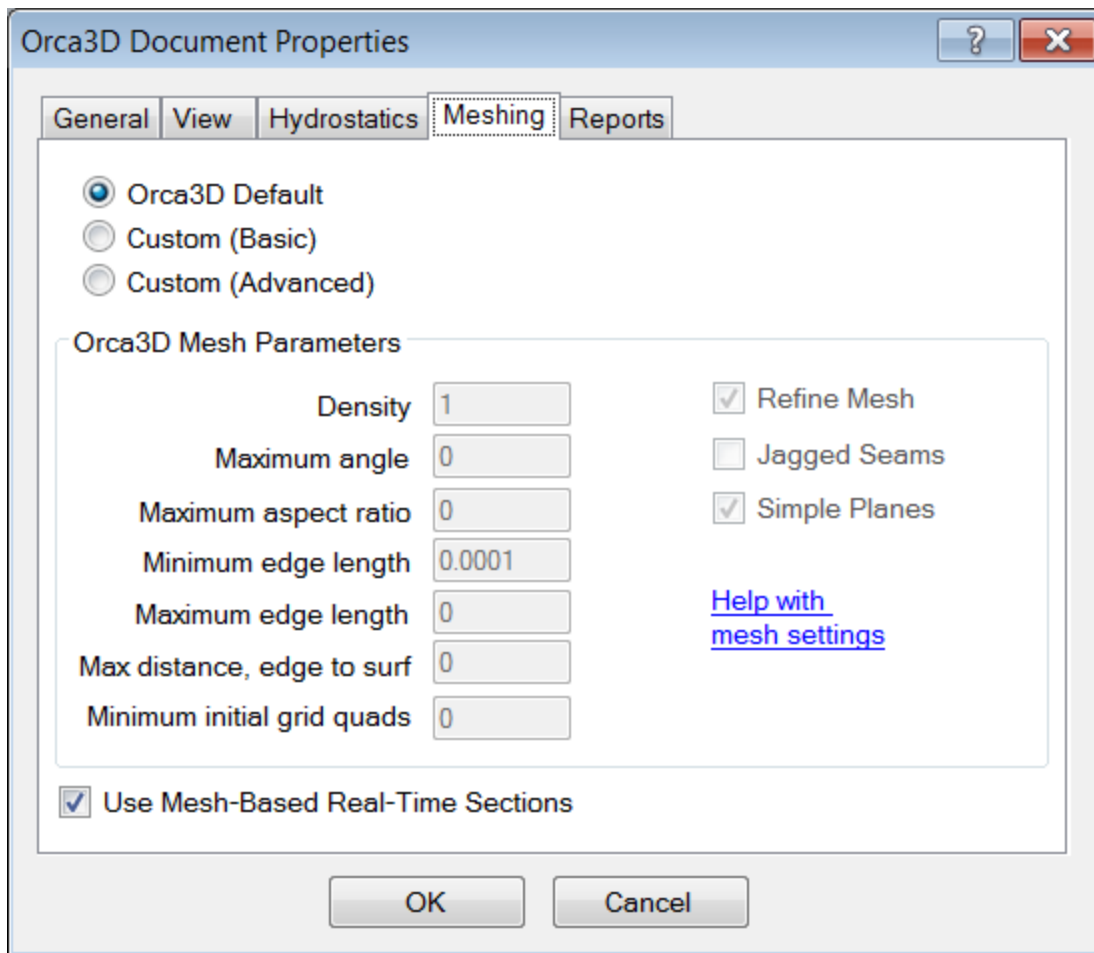
Equilibrium Warning Thresholds

When computing free-float hydrostatics (Weight is specified), Orca3D will give a warning if the equilibrium flotation condition results in a heel or trim greater than the threshold value. While this may be a valid equilibrium, it may not be the one that was expected. While the Heel and Trim values for the resultant flotation condition are shown in the report, this warning is an extra reminder to view the details of the condition. See [Hydrostatics Output](#)^[271] for more information on equilibrium flotation conditions.

Section Area Curve

When computing hydrostatics, you have the option of [adding a plane to represent the water surface](#)^[265]. This will also insert a sectional area curve, if you have defined stations. The scale and color of this curve may be specified here. The Scale Factor is defined as the number of linear units on the vertical scale of the plot per area unit of sectional area (e.g., meters/square meter).

Meshing Tab



Orca Mesh Parameters

Edit the Orca Mesh Parameters to change how Rhino computes the Orca mesh for use in hydrostatics calculations (including real-time hydrostatics) and for the real-time sections computations. For more accurate hydrostatics you want finer mesh settings (which produces denser meshes and more accurate results), but sometimes you want somewhat coarser settings for the real-time calculations to enhance speed.

The two most important values are the **Density** and the **Max Distance, Edge to Surf**. The Density value is a simple control that internally creates values for all of the other settings. All of the other settings can be changed, but won't have an effect until they reach the point where they imply a finer mesh than the Density setting. For example, with the default 10 meter sailboat from the Hull Assistant, if the Density is set to 1, there will be very little change in the mesh until the Max Distance, Edge to Surf gets below about 1 mm.

See [Mesh Density Accuracies](#)⁵³⁰ for examples of how different Density values affect various hydrostatic parameters.

There are three options:

- **Default:** The Default setting gives a Density of 1 and also turns on "Refine Mesh."

This seems to be a good setting for a wide range of geometries. It is difficult to specify a group of settings that is appropriate for all Rhino geometries because of the wide variation in shapes and topologies that can be created. The settings are most important when you have a very simple, clean control net, and a surface with a lot of curvature (for example, the default hull from the Sailboat Hull Assistant).

- **Custom (Basic):** If you select "Custom (Basic)," you have the option to change two settings.

Density: Rhino uses a formula to control how close the polygon edges are to the original surface. This is a single value, between 0 and 1, that creates values for all of the other settings (although it doesn't display them). If you set one of these other values to something finer, it overrides the value that the Density setting created. Larger values result in a mesh with a higher polygon count. The default value in Orca3D is 1.0.

Max Distance, Edge to Surf: The default value of zero implies that the value created internally by the Density setting will be used. Be careful about specifying too tight of a tolerance here or the Rhino mesher could take a very long time. A value that is about 1/10000th the size of the length of the vessel seems to be a good compromise between speed and accuracy. For example, on a 10 meter sailboat hull, leaving this value at 0 (turning the option off) with a Density of 1 will yield an error in displacement of about 0.17%. Setting it to 1 mm will reduce the error to about 0.16%, and a value of 0.5mm will reduce the error to about 0.05%, but noticeably increases computation time. On a 160 meter ship hull, leaving this value at 0 (turning the option off) with a Density of 1 will yield an error in displacement of about 0.07%. Setting it to 1 cm will reduce the error to about 0.04%. Orca does not currently display the resultant mesh, but since it uses the Rhino mesher you can see the same result by using the Rhino Mesh command which has the same controls.

- **Custom (Advanced):** With this option, you are free to change any of the parameters, which are defined as follows:

Density: Rhino uses a formula to control how close the polygon edges are to the original surface. This is a single value, between 0 and 1, that creates values for all of the other settings (although it doesn't display them). If you set one of these other values to something finer, it overrides the value that the Density setting created. Larger values result in a mesh with a higher polygon count. The default value in Orca3D is 1.0.

Maximum Angle: the maximum allowable change between the surface normal at any point and the mesh vertex. The default value in Orca3D is 0 which turns this option off.

Maximum Aspect Ratio: surfaces are initially tessellated with a regular quadrangle mesh and then that mesh is refined. The initial quad mesh is constructed so that on average, the maximum aspect ratio of the quads is less than or equal to the maximum aspect ratio. The default value in Orca3D is 0 which turns this option off.

Minimum Edge Length: if any edge is shorter than the minimum edge length, no

further division of the mesh faces occurs. The default value in Orca3D is 0.0001 units.

Maximum Edge Length: polygons are further divided until all polygon edges are shorter than this value. The default value in Orca3D is 0, which turns off this option.

Max Distance, Edge to Surf: The default value of zero implies that the value created internally by the Density setting will be used. Be careful about specifying too tight of a tolerance here or the Rhino mesher could take a very long time. A value that is about 1/10000th the size of the length of the vessel seems to be a good compromise between speed and accuracy. For example, on a 10 meter sailboat hull, leaving this value at 0 (turning the option off) with a Density of 1 will yield an error in displacement of about 0.17%. Setting it to 1 mm will reduce the error to about 0.16%, and a value of 0.5mm will reduce the error to about 0.05%, but noticeably increases computation time. On a 160 meter ship hull, leaving this value at 0 (turning the option off) with a Density of 1 will yield an error in displacement of about 0.07%. Setting it to 1 cm will reduce the error to about 0.04%. Orca does not currently display the resultant mesh, but since it uses the Rhino mesher you can see the same result by using the Rhino Mesh command which has the same controls.

Minimum Initial Grid Quads: the number of quadrangles per surface in the initial mesh grid. The default value in Orca3D is 0 which turns this option off.

Refine Mesh: after its initial meshing, Rhino uses a recursive process to refine the mesh until it meets the criteria defined by maximum angle, minimum edge length, maximum edge length, and maximum distance, edge to surface options. The default value in Orca3D is true.

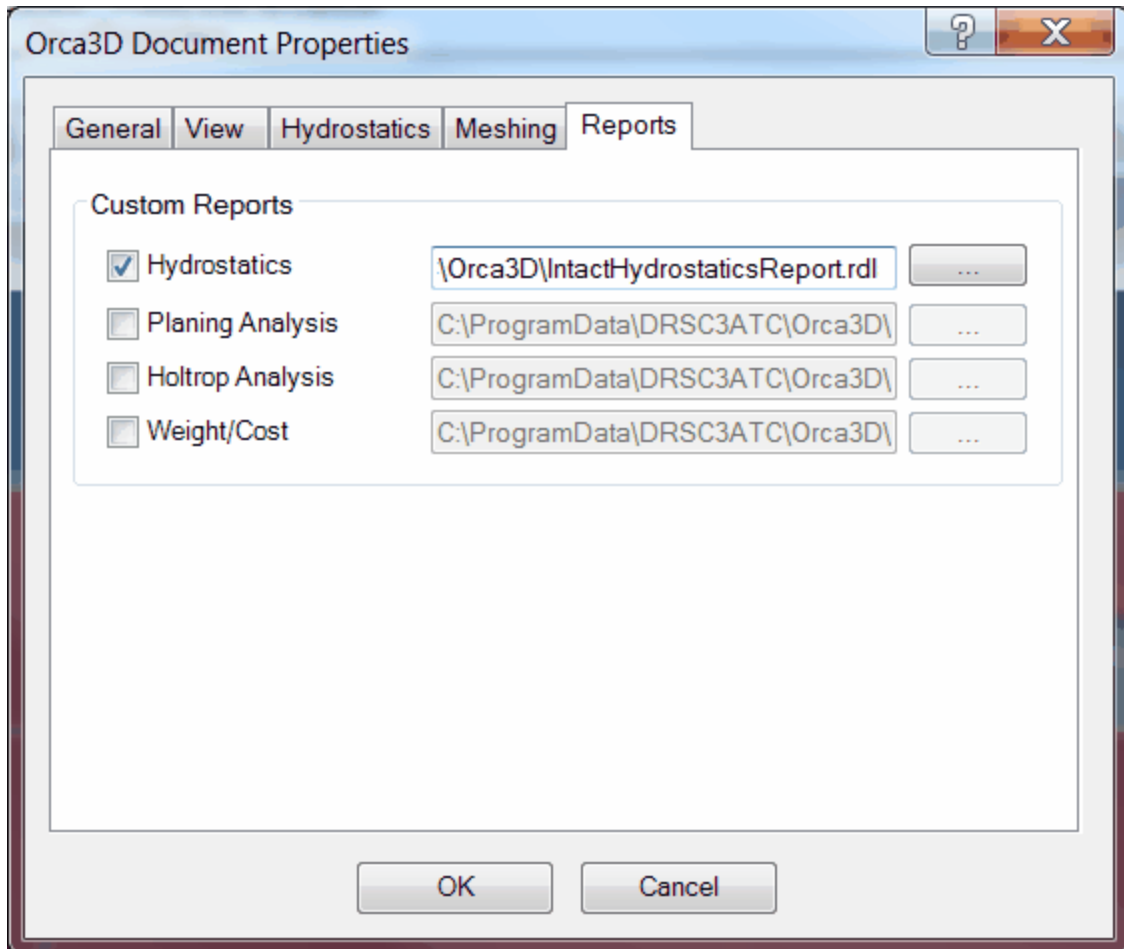
Jagged Seams: all surfaces mesh independently and Rhino does not stitch the edges of joined surfaces edges together. The default value in Orca3D is false, which means watertight meshes are created if the surfaces are joined.

Simple Planes: all planar surfaces are meshed by meshing the surface edges and then filling the area bounded by the edges with triangles. If simple planes is true, the settings, except jagged seams, are ignored for planar surfaces and the planar surface is meshed with as few polygons as possible. The default fault in Orca 3D is true.

Use Mesh-Based Real-Time Sections: Orca3D allows the user to visualize the effect of surface modifications made through editing control points on the associated section geometry in real-time as control points are moved. Historically this has been accomplished by meshing the surface being edited and sectioning the mesh because mesh/plane intersections are generally quick to compute. Recent improvements to the Rhino contouring algorithms in Rhino 5 have made it possible and even faster sometimes to compute the sections through the surface itself during control point editing operations. This option allows the user to determine which approach is used. Checking the box causes the legacy mesh-based section logic to be used. Unchecking the box causes more accurate surface-based section logic to be used. Note that the true surface-based sections are computed when a control point is released (after dragging) regardless of this option setting.

Reports Tab

The format of the various reports that Orca3D creates may be modified. The templates that are used to define the format are specified in the Reports tab of the Properties dialog. If you wish to specify a format other than the default, check the box and browse to the .rdl file that you've created. See [Custom Report Design](#)⁴⁹⁸ for more information.



Part

VI

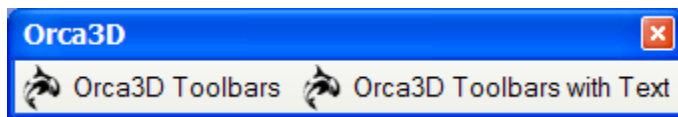
6 Quick Start Guide

These sections provide a quick introduction to using Orca3D. They are intentionally kept brief so that you can actually start using the program as quickly as possible. The objective is not to teach you every single detail but to familiarize you with the basic principles and the way the program works.

For full details on the procedures described here please refer to the sections that cover the individual modules.

6.1 Toolbars

After installing Orca3D and starting Rhino, a toolbar with two buttons will be shown:



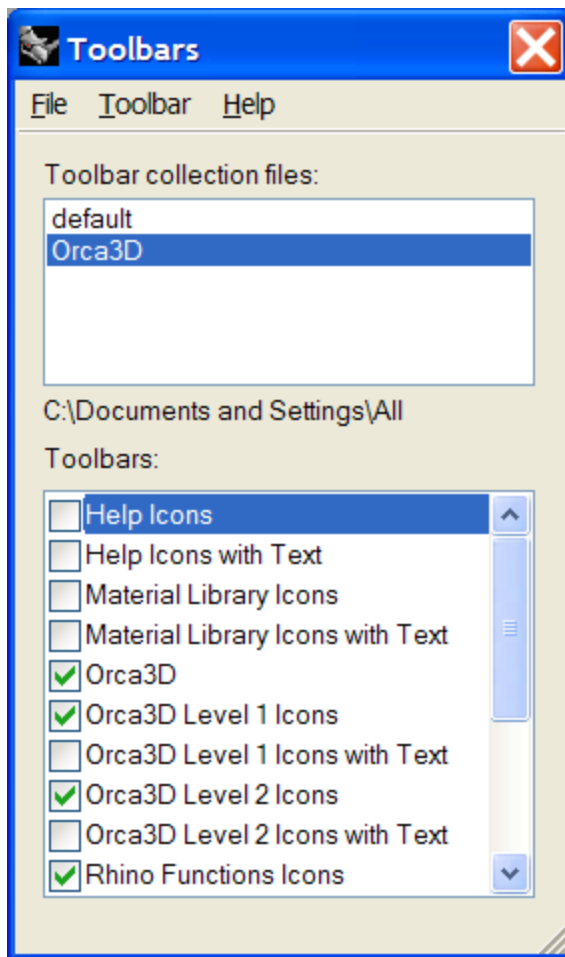
Clicking on either of these buttons will bring up the three standard Orca3D toolbars, either with or without text. While the text versions takes up more space, they can be helpful in learning the icons, especially when you're new to Orca3D.

Orca3D's toolbars are stored in the following directories:

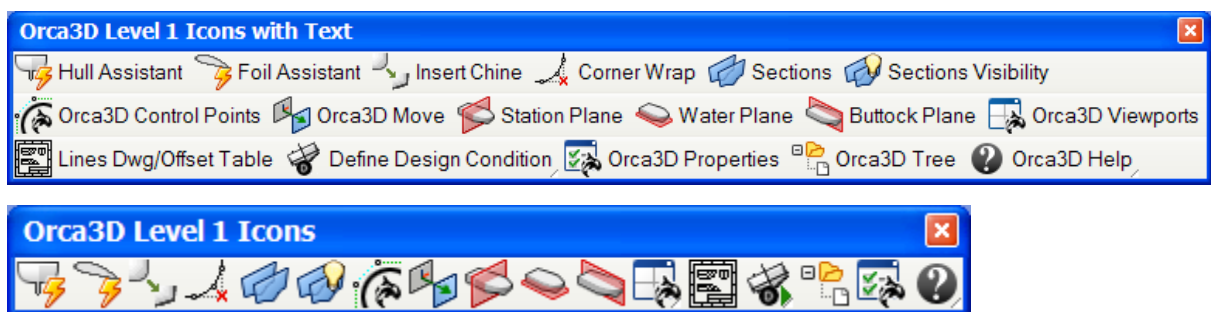
- Windows XP: C:\Documents and Settings\All Users\Application Data\DRSC3ATC\Orca3D
- Windows Vista and 7: C:\ProgramData\DRSC3ATC\Orca3D

You must have write permissions in this directory for your toolbar settings to be maintained.

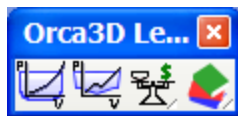
You can also decide which toolbars to display using Rhino's toolbar layout function (Tools->Toolbar Layout):



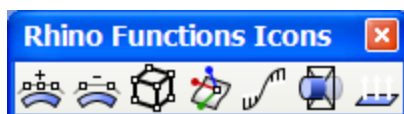
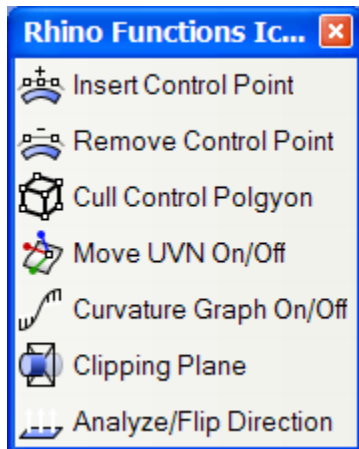
The Level 1 toolbars include functions for Hull Design & Fairing and Hydrostatics & Intact Stability, as well as miscellaneous functions such as Orca3D Properties, the Orca3D Tree, and Help.



The Level 2 toolbars include functions for Speed/Power Analysis and Weight/Cost Tracking.




The Rhino Functions toolbars contain standard Rhino functions that are not exposed on the standard Rhino toolbar layout, but can be very useful in marine design. Each of these functions is covered in the Rhino Help file.



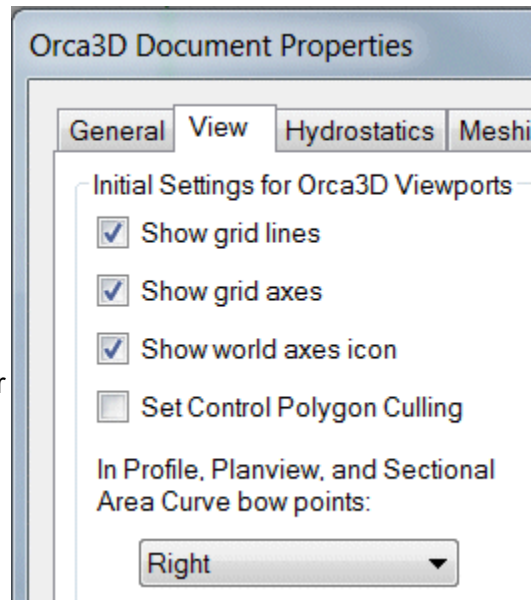
6.2 Orca3D Viewports

Orca3D Viewports

Toolbar	
Menu	Orca3D > Orca3D Viewports n/a
Command	OrcaViewports OrcaLayout

By default, Rhino displays four viewports; Top, Front, Perspective, and Right. The OrcaViewports command creates a 4-view layout, with viewports named Planview, Profile, Perspective, and Bodyplan, and implements the following optional behaviors (which are set in [Orca3D Properties](#) ⁽⁷⁷⁾):


- Grid lines
- Grid axes
- World axes icon
- Control Polygon Culling: To "de-clutter" the view of the control net, only the control points on the side of the surface that face the camera are displayed.
- In Profile and Planview, bow points: Select "right" or "left," depending on your preference. This does not change the coordinate system, simply the camera position.



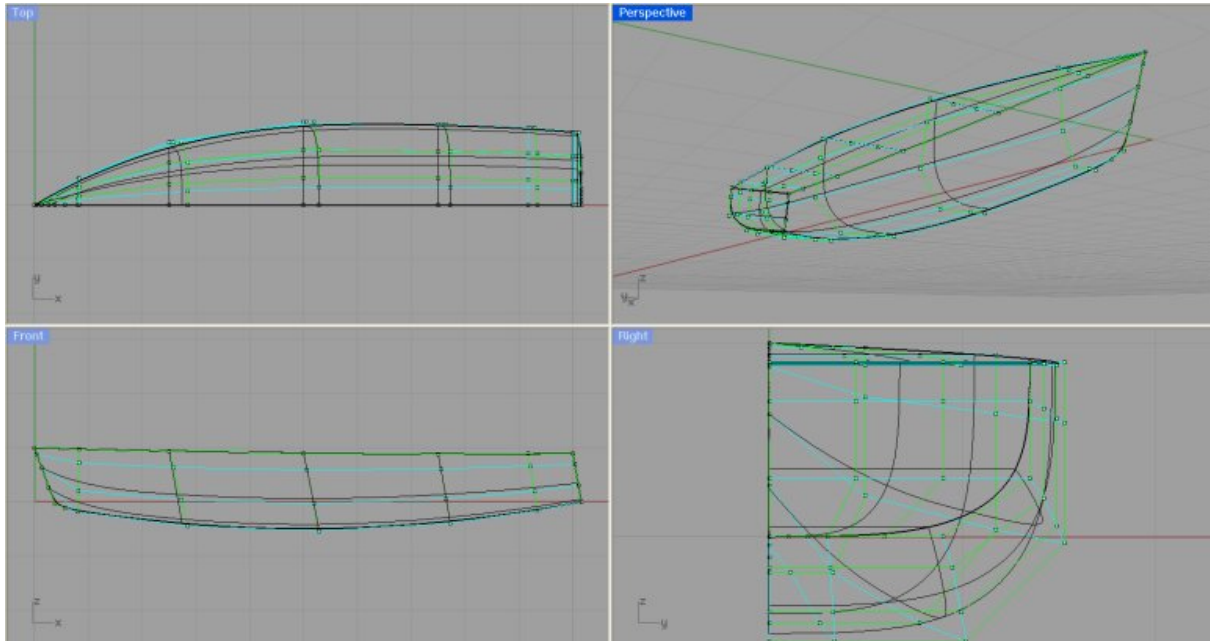
The OrcaViewports icon is defined as follows:

- Left click: OrcaViewports is executed
- Right click: Default 4-view layout is restored

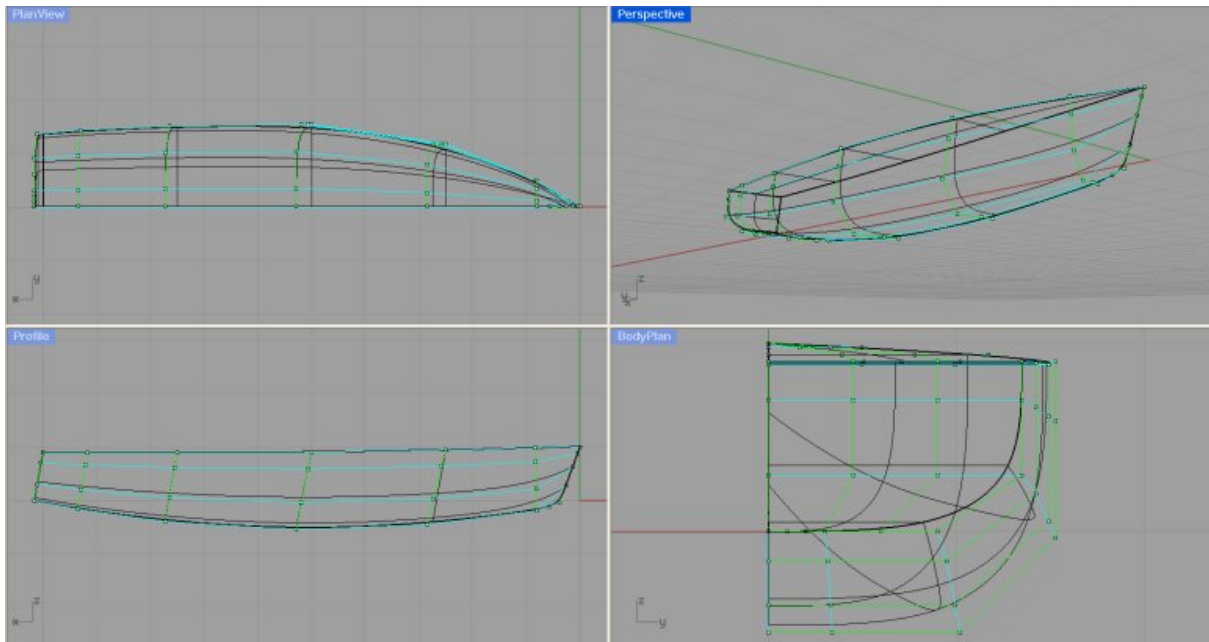
Just like any other changes that you might make to the layout of your Rhino viewports, switching to the Orca Viewports will lose your current settings. If you have set up a layout

other than Rhino's default 4-view layout, you can save (cache) it by left-clicking on the OrcaLayout icon (). Then later when you want to go back to that view, right-click on the OrcaLayout icon to restore it.

By default, the 4-view layout looks like the following:



In the following image, OrcaViewports has been invoked. Note that the viewports are renamed, the gradient is turned on, the control net culling has been enabled, and the bow is pointing to the right (notice that with control net culling on, the control points on the deck aren't visible in the perspective view and planview, and the control points in the forward half of the boat aren't visible in the bodyplan view).



6.3 Hull Assistants

This tutorial shows you the basics of creating a new hull in Orca3D using the Hull Assistants.

Toolbar	
Menu	Orca3D > Hull Design Hull Assistant
Command	OrcaHullAssistant or the scriptable commands: -OrcaCreatePlaningHull -OrcaCreateSailboat -OrcaCreateShipHull -OrcaCreateRIB

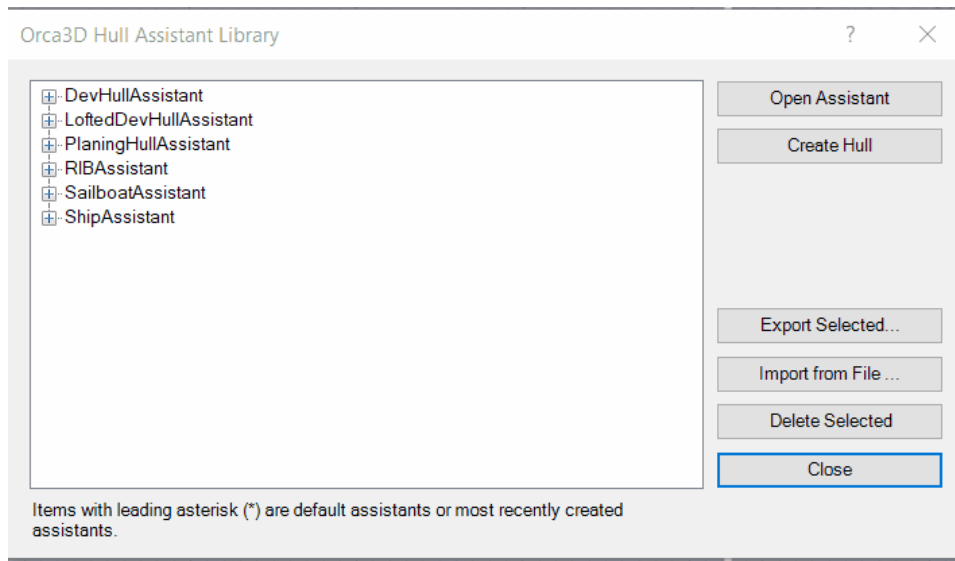
The Hull Assistants are intended to speed the process of creating a 3D surface that you can modify to create your final hull shape. While it's unlikely that they will automatically create your final hull form, they can get you close very quickly. Once the 3D surface is created, you can modify it using the Orca3D control points, watching the sections and hydrostatics updating in real-time as you go.

There are six Hull Assistants:

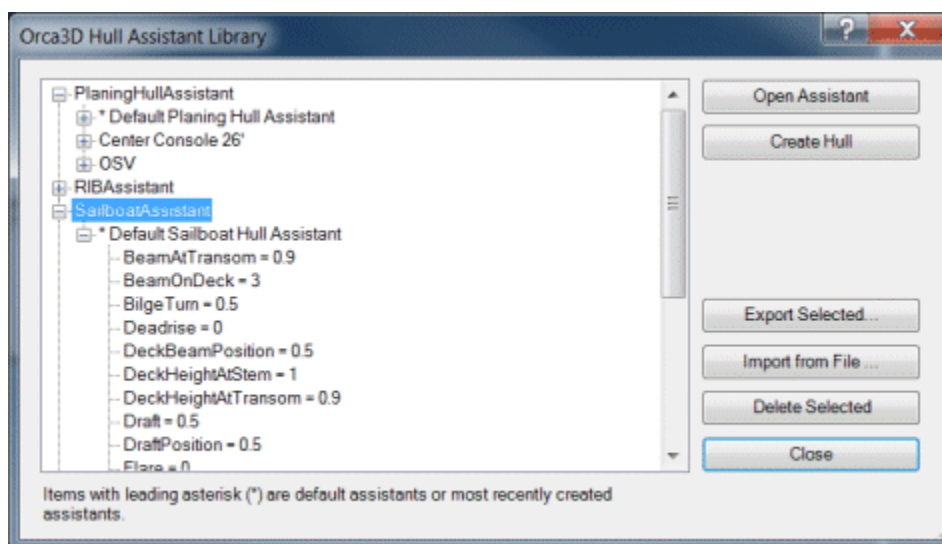
- [DevHull](#)^[175]: Developable hulls made up of portions of cones and cylinders
- [LoftedDevHull](#)^[102]: Developable hulls made using Rhino's DevLoft command
- [Planing Hull](#)^[102]: double chine hull

- [RIB](#)¹¹⁷: Rigid Hull Inflatable Boat, including the inflatable tube
- [Sailboat](#)¹⁰⁵: moderate displacement, round-bilge hull
- [Ship](#)¹⁰⁸: large commercial-type ship (no bulb)

The Hull Assistants are accessed through the Orca3D Hull Assistant Library:



Clicking on the + sign next to each assistant type will display a list of all of the saved settings for that assistant. For each of the four types, there is a default set of input values. Clicking on the + sign next to a particular assistant in the list (Default or one of your saved assistants) will show the input values for that assistant.



After you have modified any of the default values in the Hull Assistant dialog, you can save the values under a different name, so that you don't have to begin with the default values


each time. These assistants are stored on your computer, in a file called *Orca3DHullAssistants.xml*, located in the C:\ProgramData\Orca3D folder. If you wish to share a hull assistant with someone else, select the assistant and click on **Export Selected**. The recipient can then use **Import from File...** to add the assistant to their library.

To use one of the assistants, follow these steps:

1. Begin by selecting one of the Hull Assistant types from the **Hull Assistant Library** dialog, and click on Open Assistant (if you click on Create Hull, the hull will be created using the settings in the chosen assistant). The appropriate dialog will be shown:

Note that there may be more than one tab in the dialog

2. If you'd like to preview the hull as you change the parameters, check the Preview Hull box.

3. If you'd like to see sections on the preview, check the Sections box. By default, 21 evenly spaced stations will be shown. If you'd like different stations, or would also like to view buttocks and waterlines, select Define Custom Sections and then click on  to open the Add Sections dialog. The stations are used to compute section-based hydrostatics values (if

you also select Preview Hydrostatics (Cp, Ax)). If you define Custom Sections, the sections will remain defined when you click the Create Hull button.

5. To view the Control Net while you make changes to the hull assistant values, check the Preview Control Net box. This can be instructive, as you see how Orca3D alters the control point in reaction to your changes to the input values.

6. If you'd like to see the Hydrostatics as you preview, check the Preview Hydrostatics box. See [Real-Time Hydrostatics](#)^[122] for more information.

7. To save the settings as a new Assistant, change the Description field, and then click Save Settings.

8. After all of the parameters are set, click Create Hull. In the case of the Planing Hull, Sailboat, and Ship Assistants, three surfaces will be created; Hull, Deck, and Transom. The Deck and Transom surfaces are simple surfaces to close the model. In the case of the RIB Assistant, a surface for the inner portion of the tube is created, along with a polysurface to represent the outer portion of the tube, the cone at the aft end of the tube, the rigid bottom, and the transom.

Sailboat Assistant

Description: Default Sailboat Hull Assistant


Dimensions | Shape

Bow Rake Angle (deg)	35
Transom Rake Angle (deg)	-5
Sheer Height	0.9
Sheer Height Position	0.34
Beam @Transom	0.5
Deck Beam Position	0.5
Canoe Body Draft Position	0.51
Deadrise	0.1
Flare/Tumblehome	0.1
Bilge Tightness	0.5
Forefoot Shape	0.5

☒ Preview Hull
☒ Preview Sections
☒ Define Custom Sections
☐ Preview Control Net
☐ Preview Hydrostatics

[Click here for input parameter definitions ...](#)

Create Hull Cancel Save Settings Back To Hull Library

If you want to edit the hull that was just created, use **OrcaPointsOn** () to see the surface's control points. These are identical to the standard Rhino control points, except that sections will automatically update when the Orca control points are moved. Also, the hydrostatics can update in real-time as you move Orca control points, if you have selected the [Real-Time Hydrostatics](#)^[122] option in the dialog that defines the [Design Hydrostatics](#)^[132] condition.

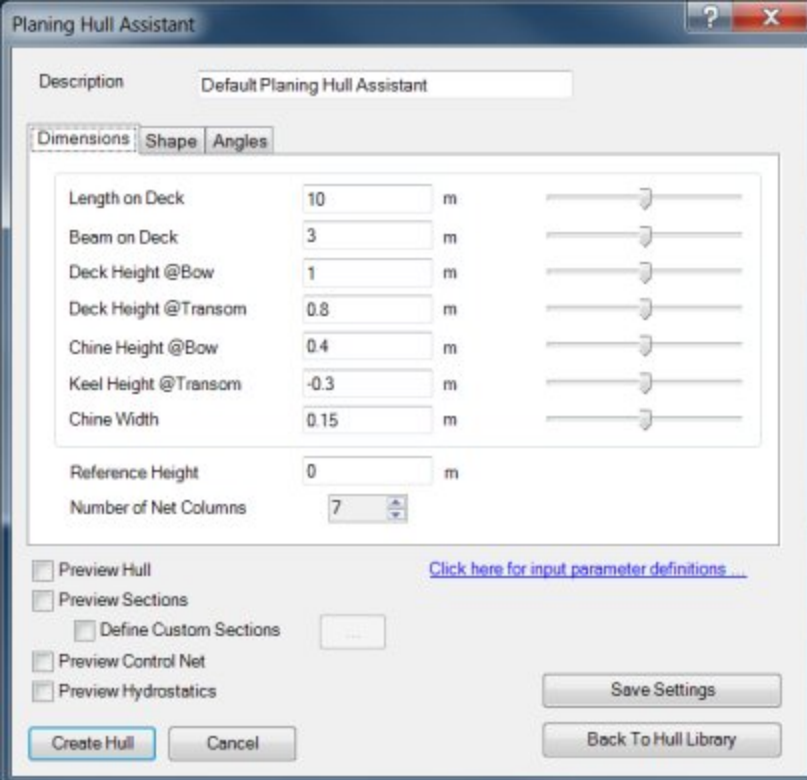
The DevHullAssistant

This assistant is described in Developable Hulls.

Definition of Input Values for the LoftedDevHull Assistant

The LoftedDevHull Assistant has the same input parameters as the Planing Hull Assistant. Using those parameters, curves are developed for the sheer, chine(s), and profile, which are then used as input to Rhino's DevLoft command.

Definition of Input Values for the Planing Hull Assistant



Planing Hull Assistant

Description: Default Planing Hull Assistant

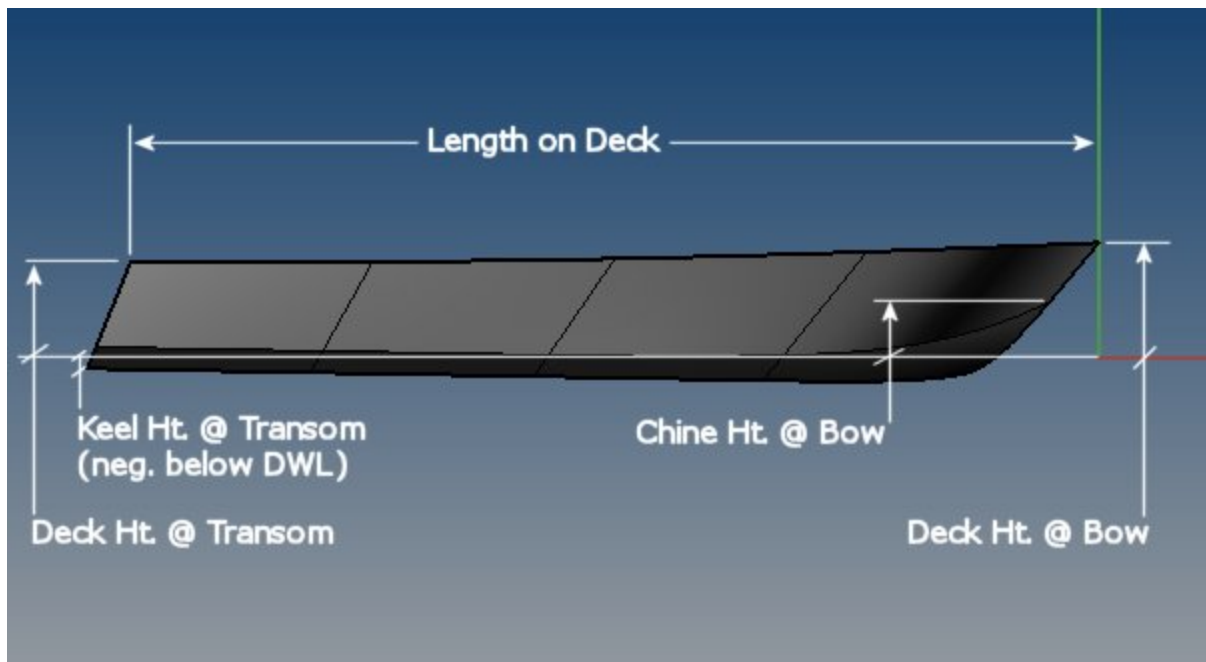
Dimensions | Shape | Angles

Length on Deck	10	m	
Beam on Deck	3	m	
Deck Height @Bow	1	m	
Deck Height @Transom	0.8	m	
Chine Height @Bow	0.4	m	
Keel Height @Transom	-0.3	m	
Chine Width	0.15	m	
Reference Height	0	m	
Number of Net Columns	7		

☐ Preview Hull
☐ Preview Sections
☐ Define Custom Sections
☐ Preview Control Net
☐ Preview Hydrostatics

[Click here for input parameter definitions...](#)

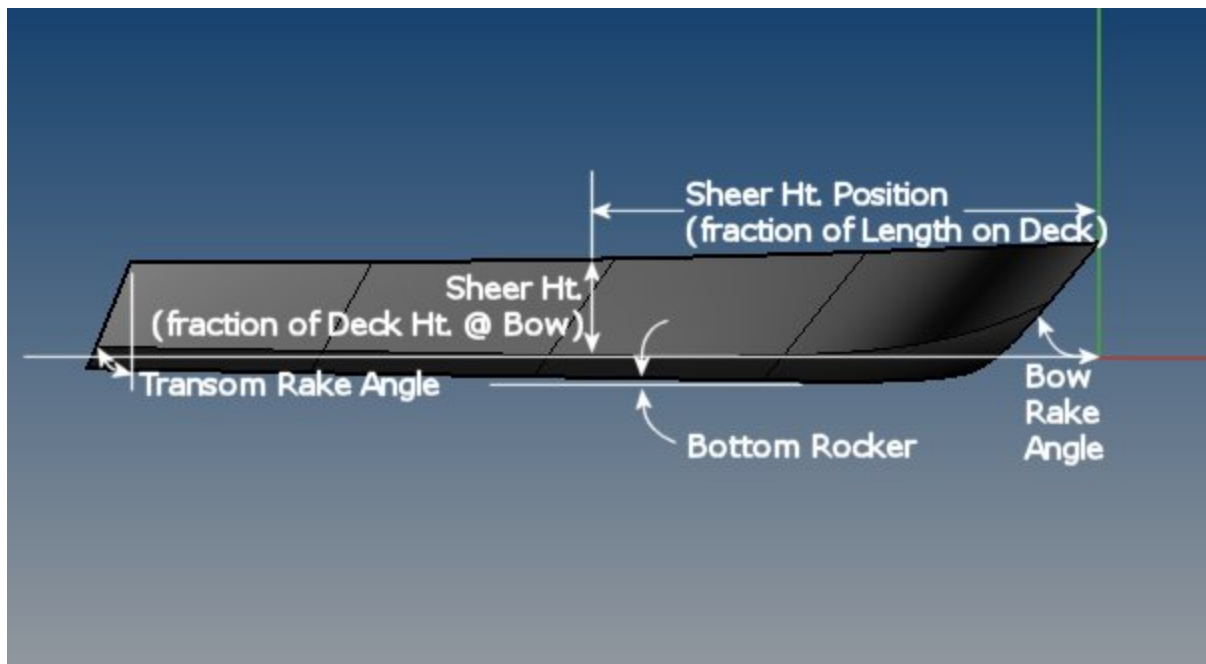
Create Hull Cancel Save Settings Back To Hull Library



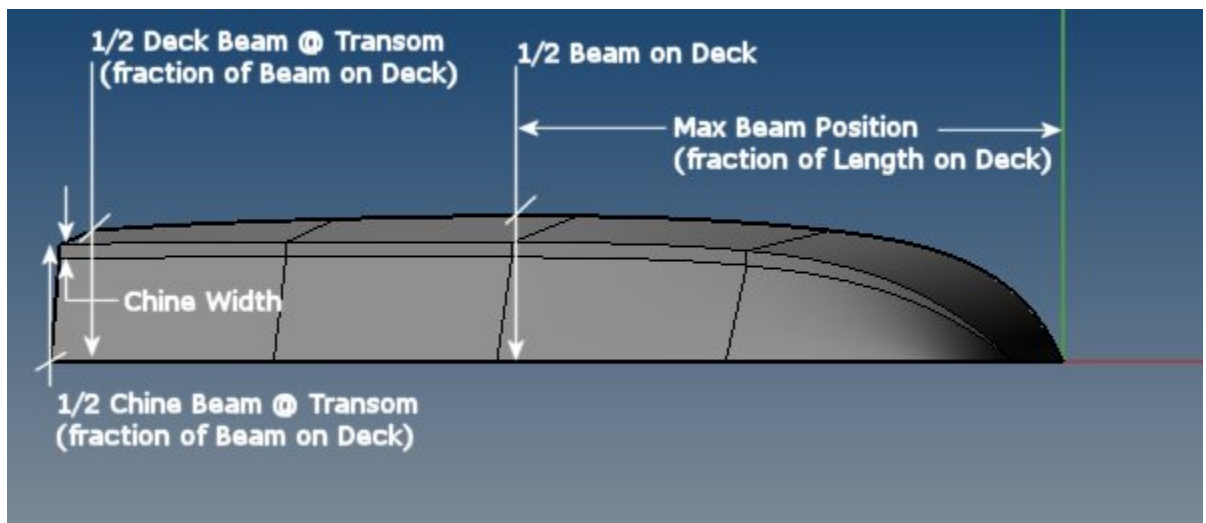
Dimensions	Shape	Angles
Sheer Height	0.9	<input type="text"/>
Sheer Height Position	0.3	<input type="text"/>
Deck Beam @ Transom	0.9	<input type="text"/>
Chine Beam @ Transom	0.8	<input type="text"/>
Max Beam Position	0.4	<input type="text"/>
Forefoot Shape	0.7	<input type="text"/>
Bow Rounding	0.5	<input type="text"/>
Bow Fullness	0.5	<input type="text"/>
Bow Twist	1	<input type="text"/>

Dimensions	Shape	Angles
Bow Rake Angle (deg)	40	<input type="text"/>
Bottom Rocker (deg)	1	<input type="text"/>
Transom Rake Angle (deg)	22	<input type="text"/>
Transom Deadrise (deg)	12	<input type="text"/>
<input type="checkbox"/> Mid Deadrise (deg)	12	<input type="text"/>
<input checked="" type="radio"/> Adjust Chine Transversely <input type="radio"/> Adjust Chine Vertically		

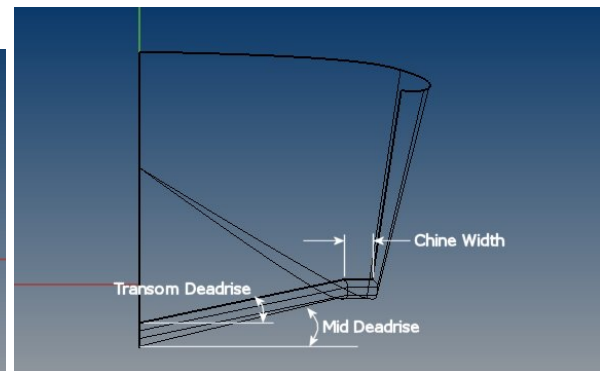
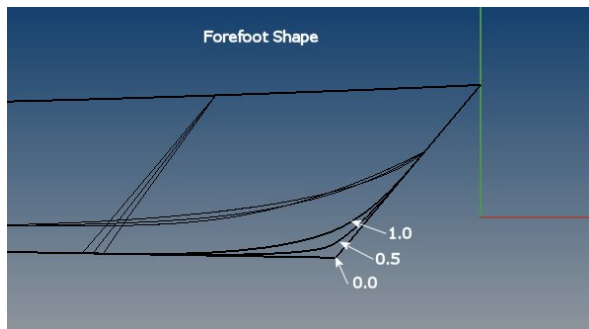
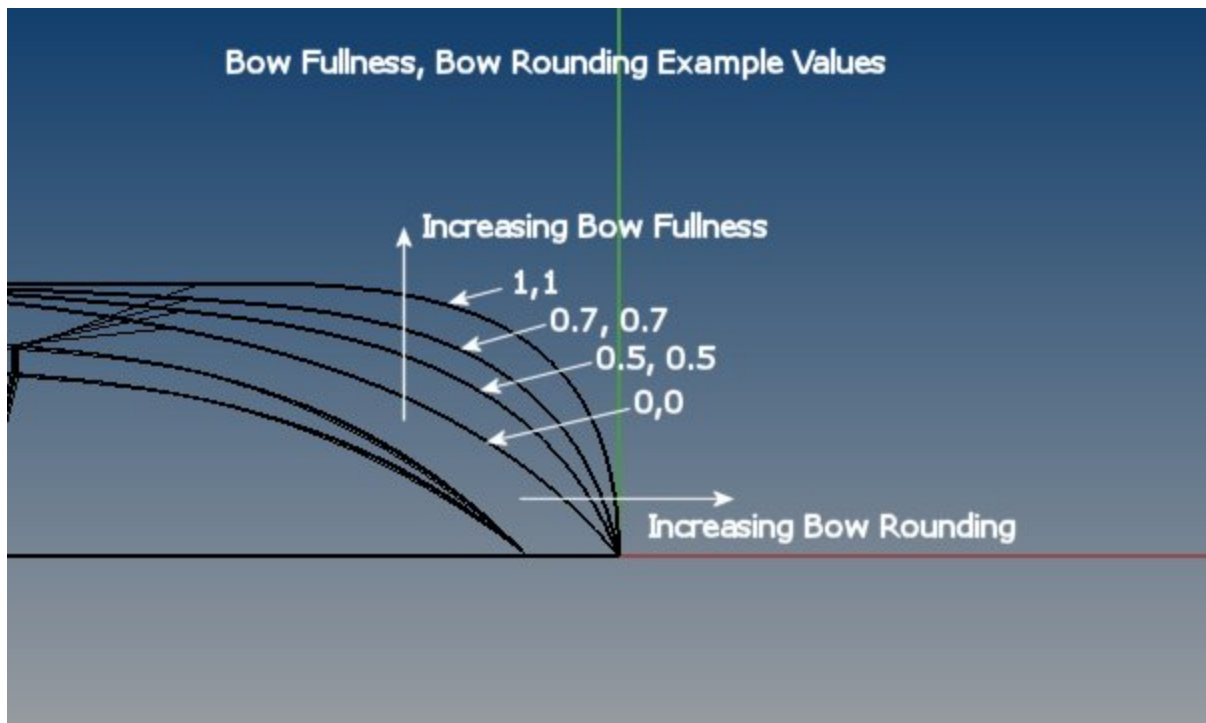
The Sheer Ht. Position is a fraction of the Length on Deck, and the Sheer Height is a fraction of the Deck Ht. @ Bow. Bottom Rocker, Bow Rake Angle, and Transom Rake Angle are in degrees.



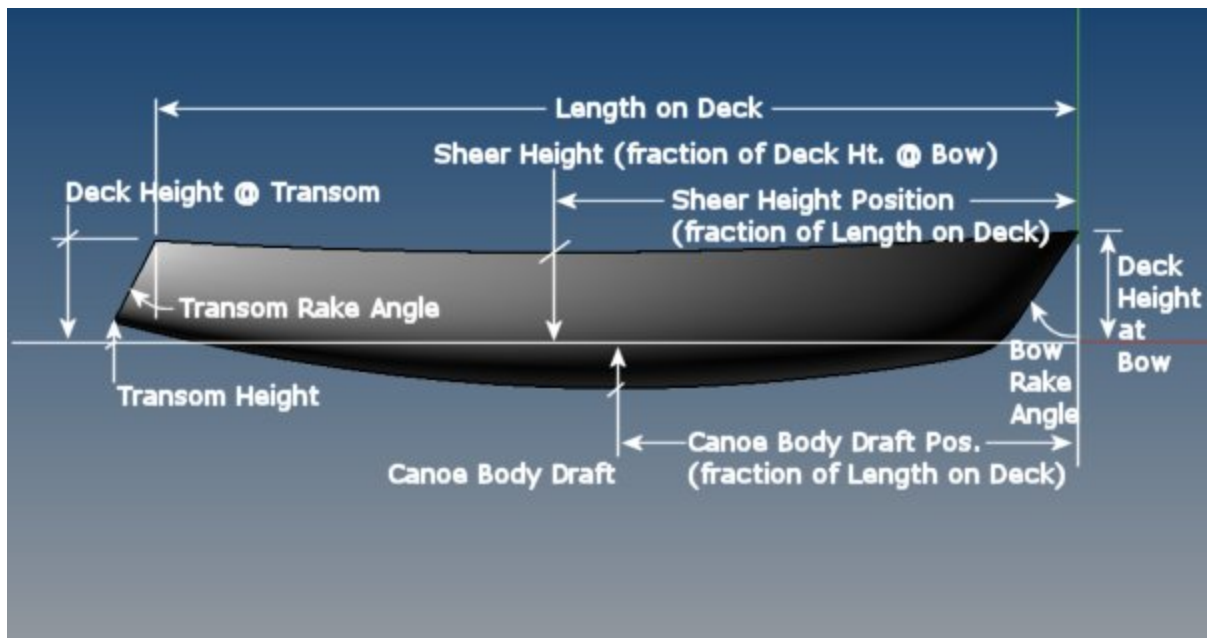
The Beam on Deck is in current length units. The Deck Beam @ Transom and Chine Beam @ Transom are fractions of the Beam on Deck, and the Max Beam Position is a fraction of the Length on Deck.



Bow Fullness and Bow Rounding control the deck shape near the bow. As Bow Fullness is increased, the maximum deck beam is carried further forward. As the Bow Rounding is increased, the deck edge becomes more perpendicular to centerplane.

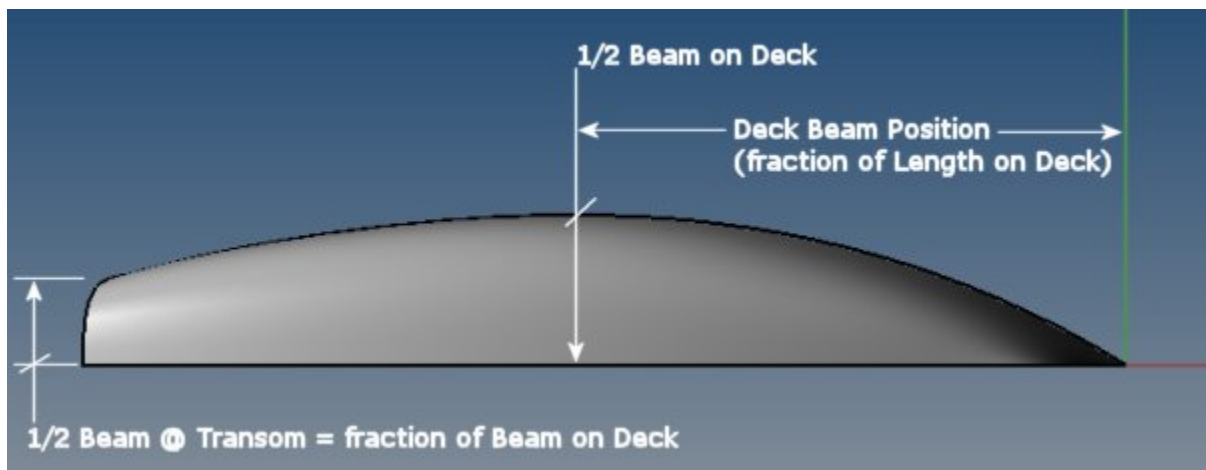


Definition of Input Values for the Sailboat Assistant

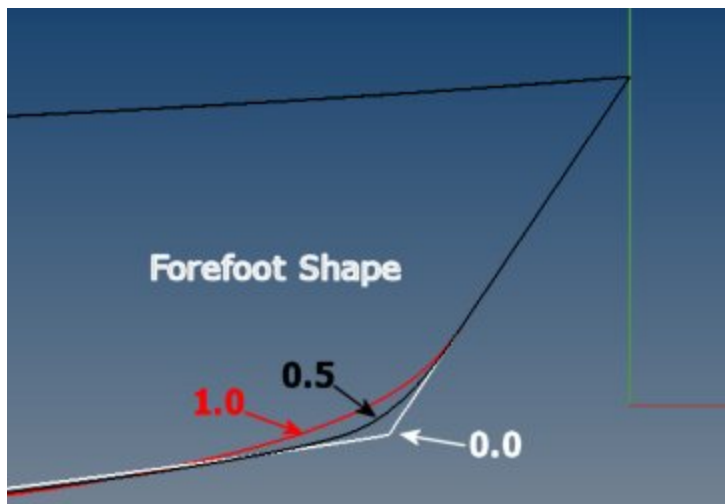


The Sheer Height Position and Canoe Body Draft Position are both a fraction of the Length on Deck. The Sheer Height is a fraction of the Deck Height at Bow. Transom Rake and Bow Rake Angle are in degrees, and the other values are in the current length units.

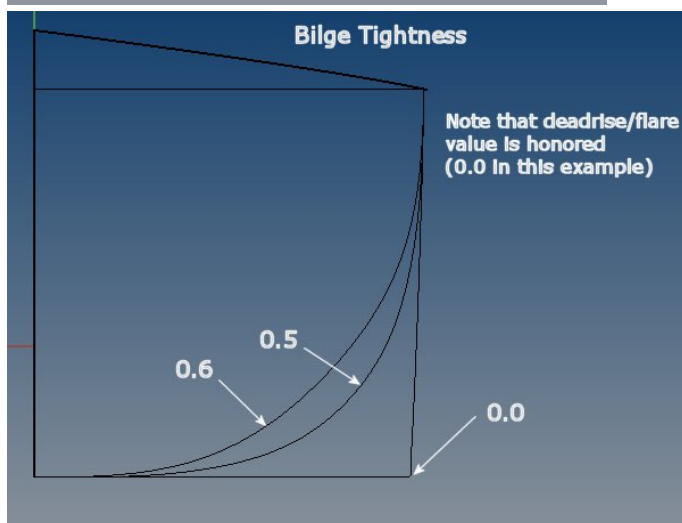
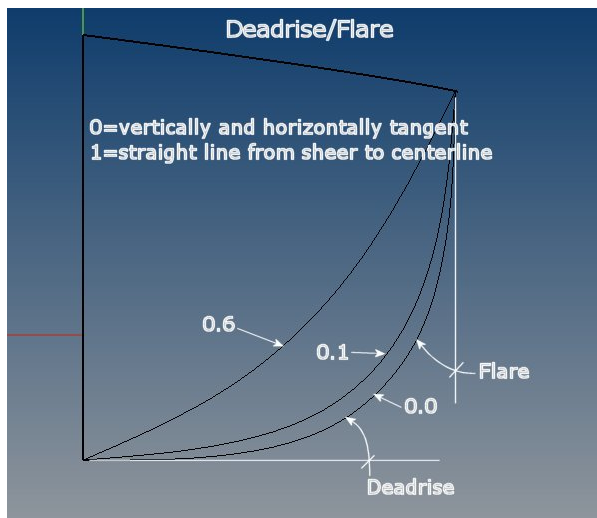
The profile of the sheerline is constructed as an arc. The three points that define the arc are the stem, the transom corner, and the Sheer Height/Position. Similarly, the bottom profile is an arc, defined by the transom height, the forefoot (whose "tightness" is controlled by the Forefoot Shape), and the Canoe Body Draft/Position.



The Beam on Deck is entered as the total beam. The Beam @ Transom is defined as a fraction of the Beam on Deck (i.e. a Beam @ Transom of 1.0 would imply no longitudinal taper).



A forefoot shape of 0.0 yields a sharp corner (discontinuity), and a value of 1.0 yields a very "soft" forefoot.



The Deadrise value controls the slope of the surface as it runs from the bilge toward the centerline, and the Flare value controls the shape as it moves up from the bilge towards the sheer. A Deadrise value of 0.0 means that the surface will approach the centerline horizontally, and a Flare value of 0.0 means that the surface will approach the sheer vertically.

The shape of the hull is also controlled by the Bilge Tightness. A value of 0.0 yields a very tight corner. The higher the value, the more slack the bilge will be. Bilge Tightness and Deadrise/Flare are interrelated, so some experimentation with these values (with Preview) turned on may be required to attain the desired shape.

Definition of Input Values for the Ship Hull Assistant

The Ship Hull Assistant has four tabs; Dimensions, Hull Form, Bow/Transom, and Bulb controls. The various input parameters are described below, but the best way to learn about the controls is to experiment with them. By checking either Preview Hull (which shows the edge curves and isoparms) or Preview Sections (which displays 21 evenly spaced stations and the edges, or you can define your own section locations), you can see the hull change in real time as you adjust the various parameters. With the Preview Control Net option, you can see how the Hull Assistant is moving the control points to define the model. By checking Preview Hydrostatics, you can see various hydrostatics parameters update as you modify the controls (note that on the Real-Time Hydrostatics display, you can select which hydrostatic parameters to view).

When you are happy with the shape of the hull, simply click on Create Hull. The Ship Hull Assistant will close, and the hull is created, together with matching flat deck and transom surfaces. If you'd like to save the settings to use as a starting point for your next design, enter a Description at the top of the dialog, and click on Save Settings. If you already have saved the settings with the same Description, you will be asked if you want to overwrite them.

Ship Hull Assistant ? X

Description Default Ship Hull Assistant

Dimensions Hull Form Bow / Transom Bow Bulb

Length On Deck	160	m	
Beam On Deck	25	m	
Depth @ Bow	18	m	
Depth @ Transom	18	m	
Draft	8	m	
Transom Height (abv BL)	5	m	
Number of Net Rows	9		
Number of Net Columns	12		

☐ Preview Hull [Click here for input parameter definitions ...](#)

☐ Preview Sections

☐ Define Custom Sections

☐ Preview Control Net

☐ Preview Hydrostatics

Create Hull Cancel Save Settings Back To Hull Library

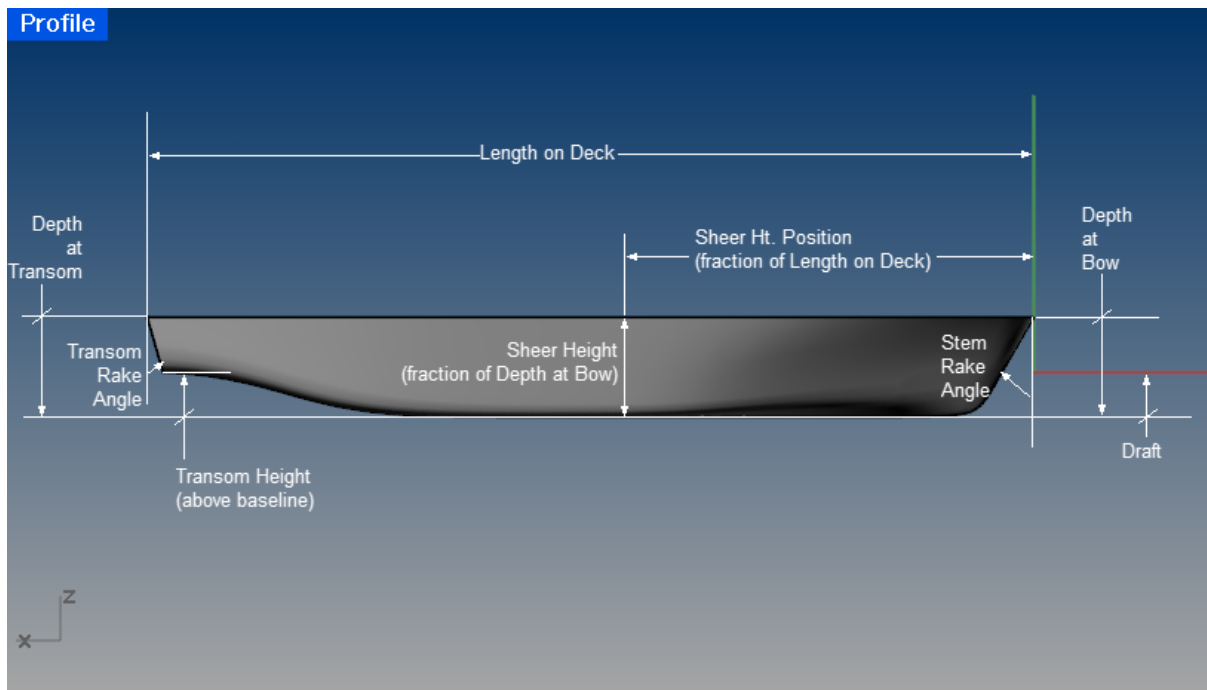
Max Area Location		0.5	
Long'l Prismatic Control		0.25	
Section Tightness	Fwd	0.67	
	Mid	0.6	
	Aft	0.8	
Deadrise	Fwd	0.1	
	Mid	0	
	Aft	0	
Side Slope	Fwd	0.9	
	Mid	0	
	Aft	0.1	
Flare	Fwd	0.6	
	Mid	0	
	Aft	0	
Sheer Height		1	
Sheer Height Position		0.5	
Fullness	Fwd	0.4	
	Aft	0.4	

Stem Rake (deg)		30	
Stem Curvature		0	
Bow Rounding		0.2	
Forefoot Shape		0.6	
Transom Rake (deg)		-10	
Transom Deck Width		0.6	
Keel Rise Point		0.7	
	Vel0	0.3	
	Vel1	0.2	

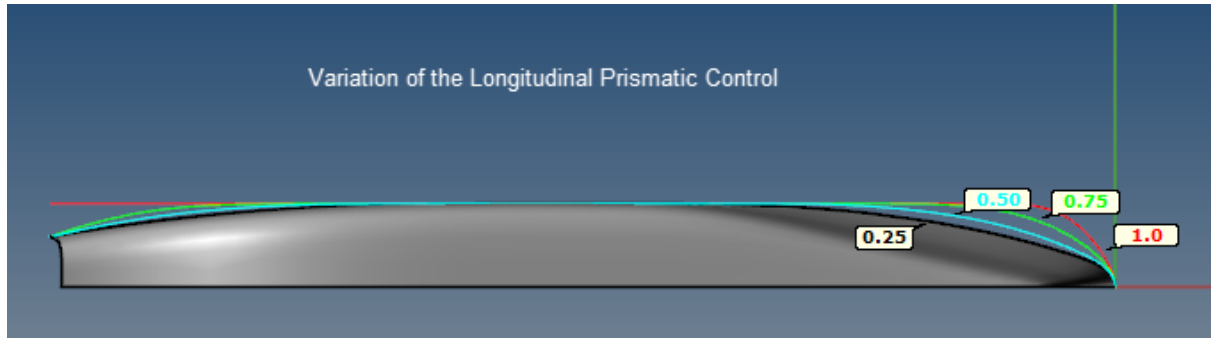
☐ Create Bulbous Bow

Length	5		units
Baseline Width	3		units
Height Fraction	0.9		
Cutwater Height Fraction	0.6		
Width Fraction - High	1.0		
Width Fraction - Low	1.0		
Tip Height Fraction	0.5		<input checked="" type="checkbox"/> Default
Tip Width Fraction	1.0		
Fairing Factor	1.0		
Bottom Profile	0.5		

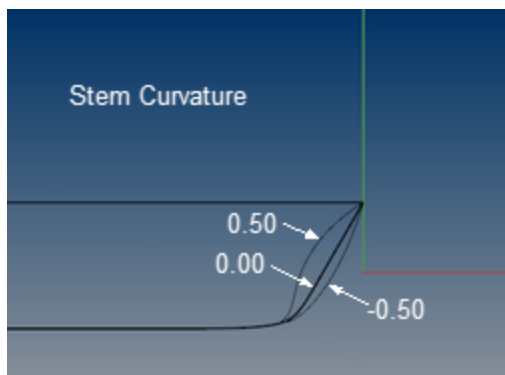
Dimensional values are displayed in the following figure. Note that some of the values are actual dimensional values (in length units or degrees), and some are expressed as ratios. For example, the sheer is defined by three points; the tip of the stem, the transom/deck intersection, and a third Sheer Height point. This point is defined by the Sheer Height (a fraction of the Depth at Bow), and the Sheer Height Position, a fraction of the Length on Deck (which defines the longitudinal location of the Sheer Height point).



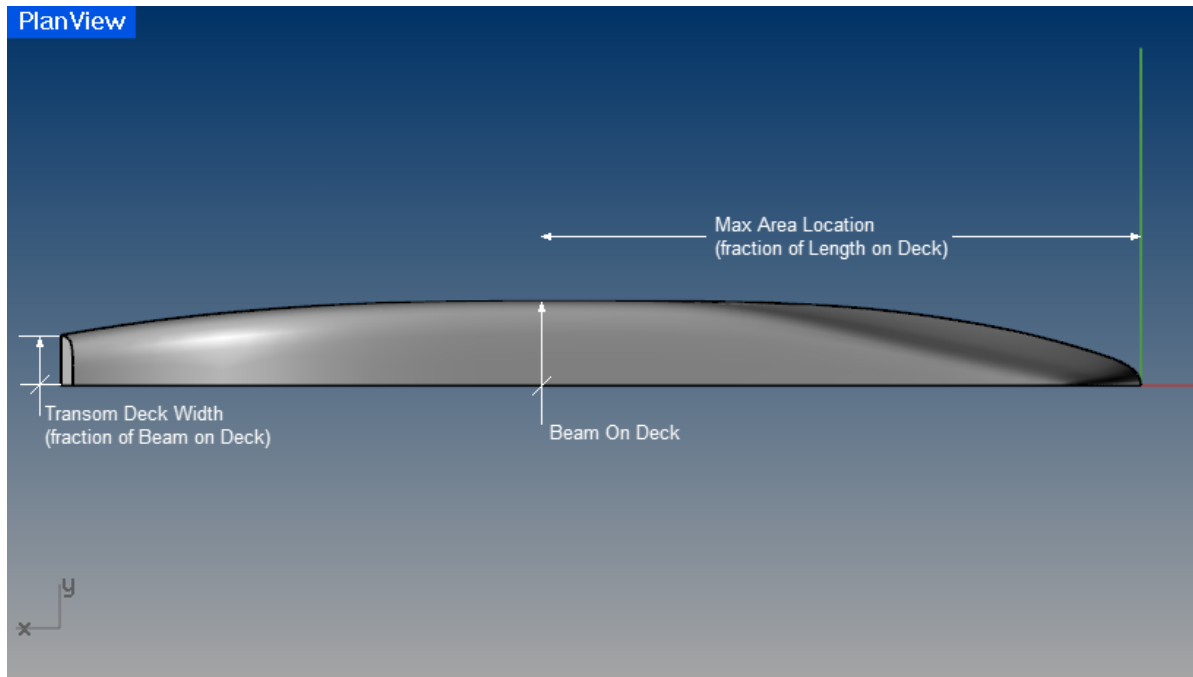
The Longitudinal Prismatic Control shifts volume to the ends of the hull (higher value), or away from the ends (lower value). Volume is shifted to the ends by making progressively more columns in the control net the same shape as the column in the Max Area location.



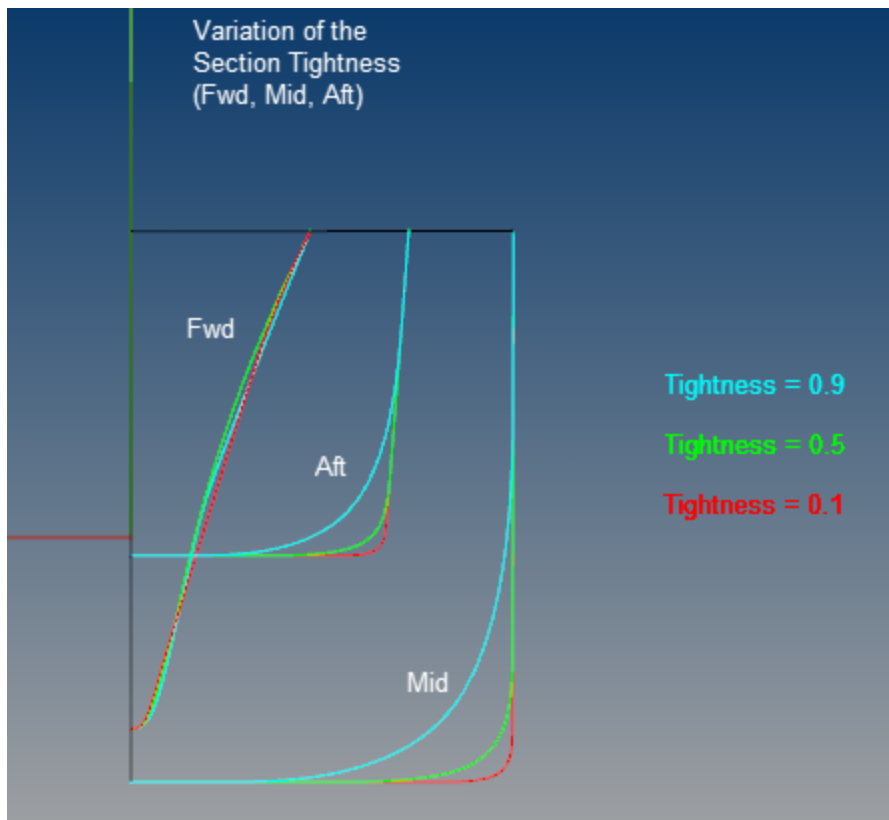
The Stem Curvature controls the shape of the stem in profile. A value of 0 yields a straight stem; positive values result in a clipper bow.



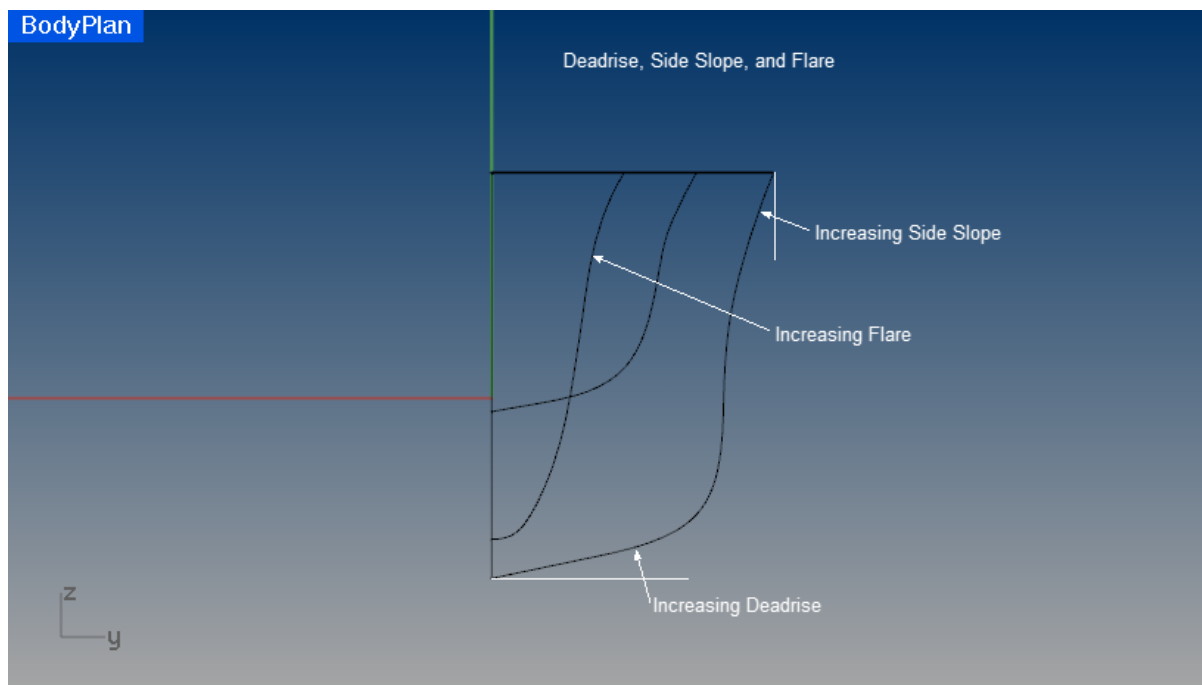
The Beam On Deck is a dimensional value (meters, feet, etc.). The Transom Deck Width is expressed as a fraction of the Beam on Deck.



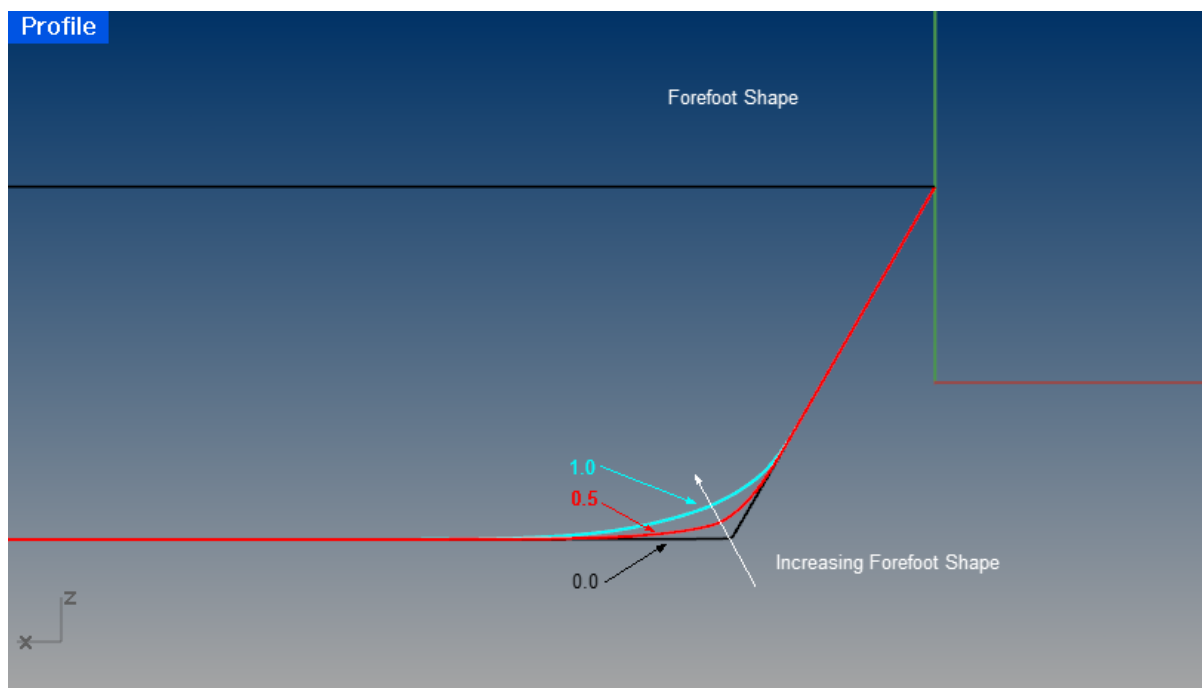
© 2018, 2019, 2020, 2021 by Orca3D, LLC, all rights reserved



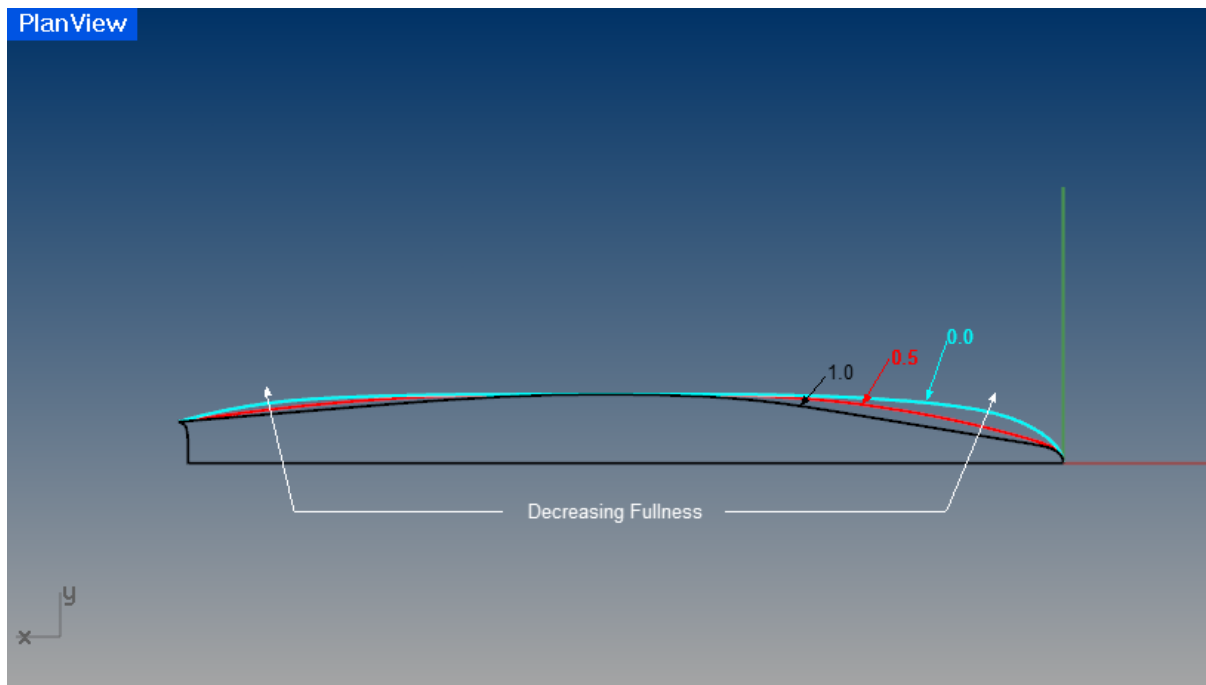
In addition to Section Tightness, there are three other controls on section shape; Deadrise, Side Slope, and Flare, each of which are specified at Forward, Mid, and Aft locations. Deadrise controls the angle of the section as it moves outward from the centerline. Side Slope controls the angle of the sections as they move down from the sheerline. Flare introduces curvature into the sections in the topsides.



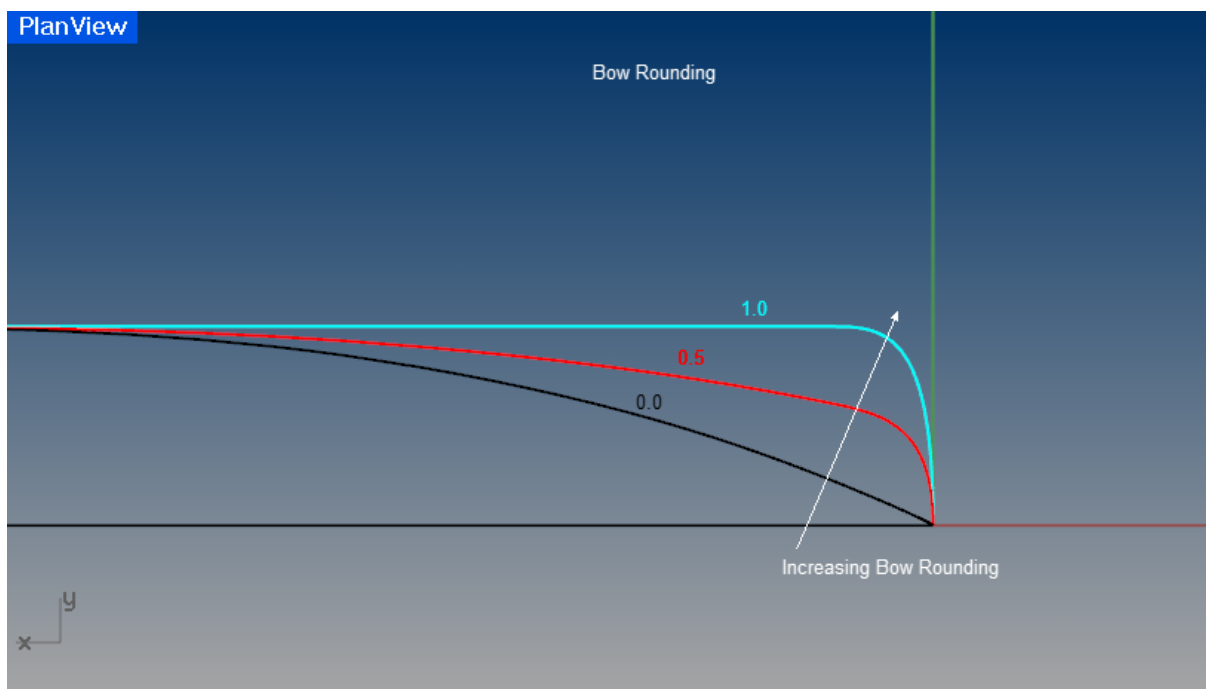
The Forefoot Shape control allows for a very "tight" or "loose" corner between the centerline profile curve and the stem curve. Curvature continuity is guaranteed, unless a value of 0.0 is entered (sharp corner).



Fullness, which has controls for both fore and aft, gradually scales the control columns in or out.

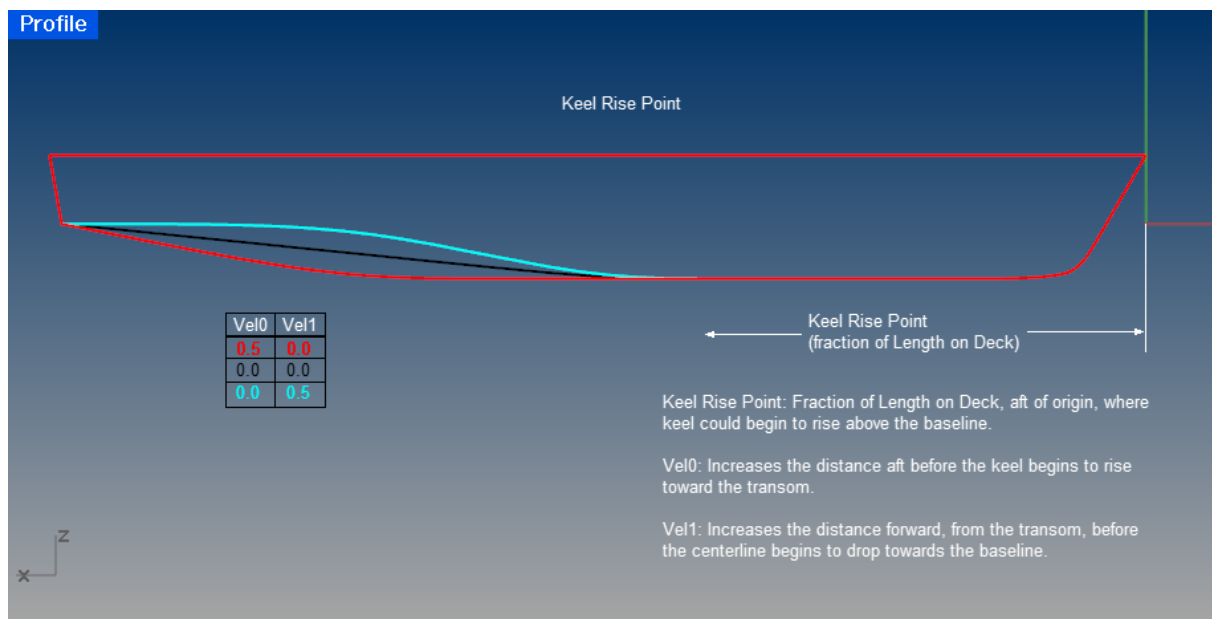


The Ship Hull Assistant is constructed with a tangency control column just aft of the stem, which always ensures that the waterlines will end perpendicular to the centerplane. The Bow Rounding control determines how far out this perpendicularity extends, by moving the tangency control column inboard and outboard. Note that other controls, such as the Deck Taper, use this column in the control net to determine the location of other columns, so the influence of adjusting the Bow Rounding will be faired into the rest of the hull.



That shape of the centerline in the aft portion of the hull is controlled by three parameters:

- **Keel Rise Point:** This is the location where the keel could begin to rise above the baseline. It is expressed as a fraction of Length on Deck, aft of the origin.
- **Vel0:** Increasing Vel0 pushes the point where the keel begins to rise further aft. The valid range is 0 to 1.
- **Vel1:** Increasing Vel1 increases the distance forward of the transom where the centerline begins to drop towards the baseline.



Bow Bulb Parameters: These parameters are easily visualized by sliding the controls to experiment with different settings. It's especially helpful to check the "Preview Control Net" box when doing so.

Length: Approximate length of the bulb from the cutwater to the tip. The length is affected by other factors, so this is approximate.

Baseline Width: Approximate maximum width of the bulb. The actual width is affected by other factors, so this is approximate.

Height Fraction: Fraction of the Draft, from the Baseline up to the Waterline, of the height of the top of the bulb. A value of 1 puts the top of the bulb at the Waterline.

Cutwater Height Fraction: Controls the height of the stem/bulb intersection.

Width Fraction: (High and Low): These parameters affect the cross-sectional shape and can be modified independently to attain the desired shape.

Tip Height Fraction: Controls the height of the control net point that defines the tip of the bulb, as a percentage of the height of the control net point that defines the forward end of the top of the bulb

Tip Width Fraction: Controls the breadth of the bulb at the tip

Fairing Factor: Controls the width of the transition from the bulb to the hull

Bottom Profile: Controls the keel/bulb intersection. A value of 1 will produce a sharp corner; lower values produce a looser curve

Definition of Input Values for the RIB Hull Assistant

The Ship Hull Assistant has three tabs; Dimensions, Hull Form, and Bow/Transom controls. The various input parameters are described below, but the best way to learn about the controls is to experiment with them. By checking either Preview Hull (which shows the edge curves and isoparms) or Preview Sections (which displays 21 evenly space stations and the edges, or you can define your own section locations), you can see the hull change in real time as you adjust the various parameters. With the Preview Control Net option, you can see how the Hull Assistant is moving the control points to define the model. By checking Preview Hydrostatics, you can see various hydrostatics parameters update as you modify the controls (note that on the Real-Time Hydrostatics display, you can select which hydrostatic parameters to view).

When you are happy with the shape of the hull, simply click on Create Hull. The RIB Hull Assistant will close, and the hull is created. If you'd like to save the settings to use as a starting point for your next design, enter a Description at the top of the dialog, and click on Save Settings. If you already have saved the settings with the same Description, you will be asked if you want to overwrite them.

The screenshot shows the 'RIB Assistant' dialog box. At the top, there is a 'Description' field containing 'Default RIB Assistant'. Below this are three tabs: 'Dimensions', 'Shape', and 'Angles'. The 'Dimensions' tab is active, displaying a list of parameters with input fields and sliders:

Parameter	Value	Unit
Hull Length	5	m
Hull Beam	1.9	m
Hull Height @Bow	0.2	m
Hull Height @Transom	-0.1	m
Chine Width	0.1	m
Tube Diameter	0.55	m
Tube End Offset	0.3	m
Reference Height	0	m
Number of Net Columns	7	

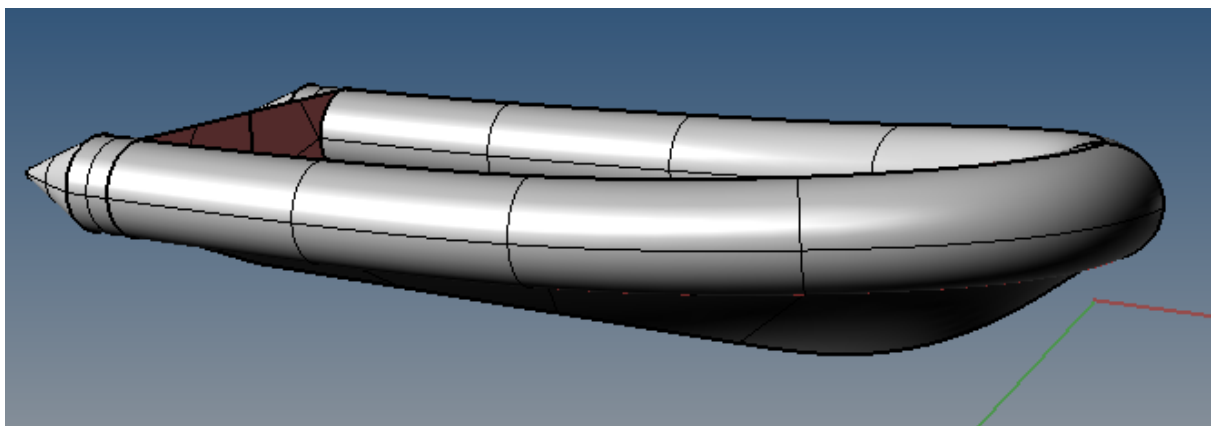
Below the parameters, there are several checkboxes for preview options:

- ☐ Preview Hull
- ☐ Preview Sections
 - ☐ Define Custom Sections (with a button labeled '...')
- ☐ Preview Control Net
- ☐ Preview Hydrostatics

At the bottom, there are three buttons: 'Create Hull' (highlighted in blue), 'Cancel', and 'Save Settings'. A link 'Click here for input parameter definitions...' is also present. A 'Back To Hull Library' button is located at the bottom right.

Dimensions	Shape	Angles
Sheer Height	-0.5	
Sheer Height Position	0.3	
Deck Beam @Transom	1	
Tube End Radius Factor	0.1	
Max Beam Position	0.5	
Forefoot Shape	0.6	
Bow Rounding	0.8	
Bow Fullness	0.1	

Dimensions	Shape	Angles
Bow Rake Angle (deg)	50	
Transom Deadrise (deg)	24	
<input type="radio"/> Constant Transom-Mid Deadrise		
<input type="radio"/> Mid Deadrise (deg)	30	
<input checked="" type="radio"/> Bottom Rocker (deg)	0.2	



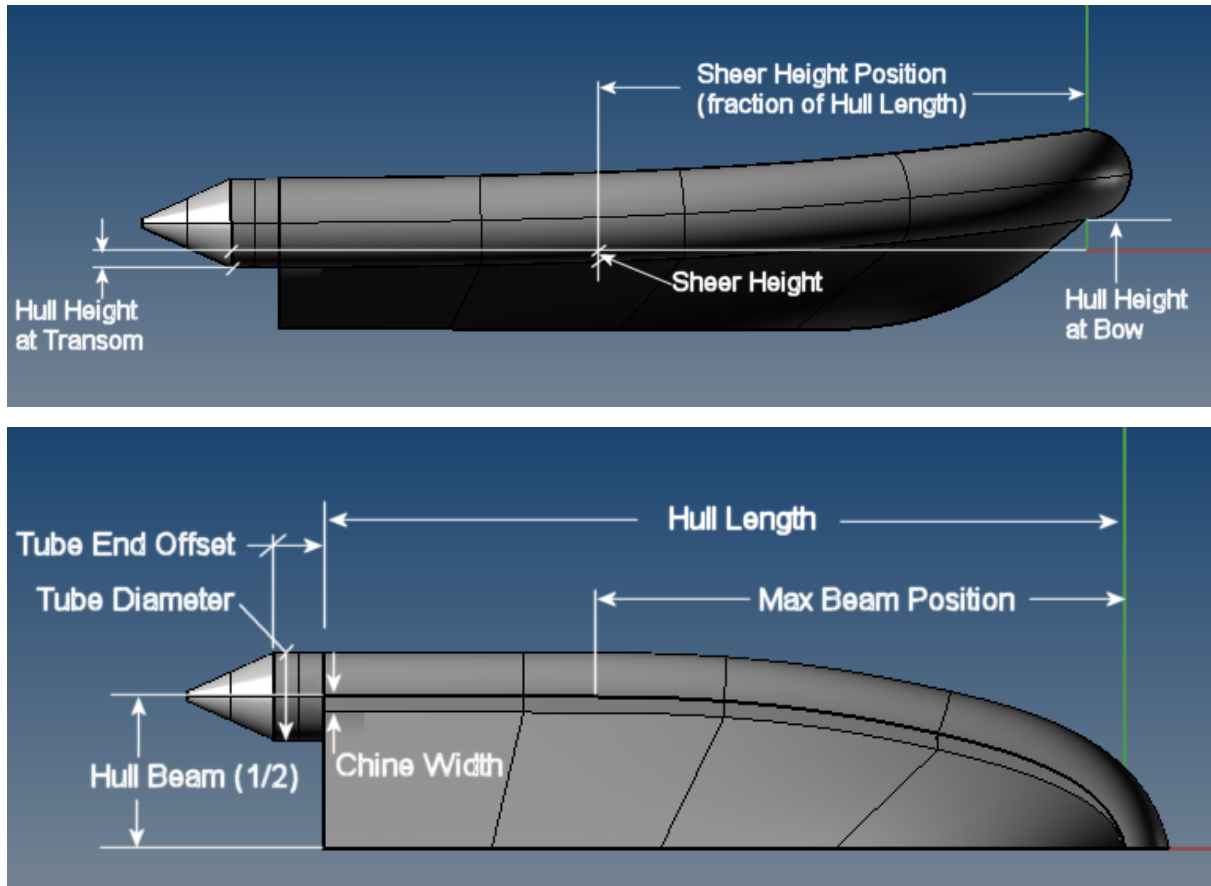
The input values are displayed in the following figures. The *Reference Height* is used for Hydrostatics calculations. The hull is built with a default waterline value of 0; for hydrostatics at a different waterline height, enter a different value for the *Reference Height*.

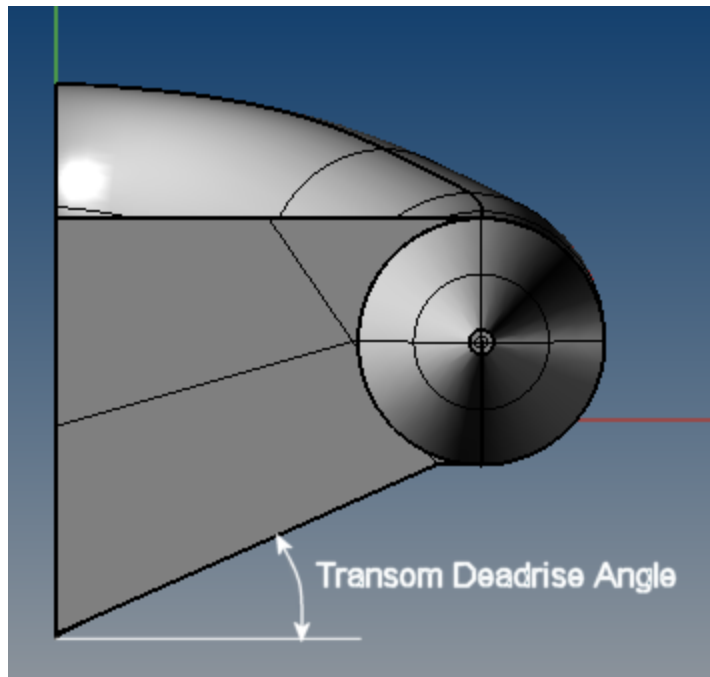
Note that some of the values are actual dimensional values (in length units or degrees), and some are expressed as ratios. For example, the sheer is defined by putting control points on an arc that is defined by three points; the *Hull Height @ Bow* of the rigid hull, the *Hull Height @ Transom* of the rigid hull, and a third *Sheer Height* point. This point is defined by the *Sheer Height* (a fraction of the *Hull Height @ Bow*), and the *Sheer Height Position*, a fraction of the *Hull Length* (which defines the longitudinal location of the Sheer Height point).

The *Tube End Radius Factor* is the ratio of the diameter of the aft end of the cone section to

tube diameter. For definitions of *Bow Rounding*, *Bow Fullness*, *Forefoot Shape*, *Bottom Rocker*, and *Bow Rake Angle*, refer to the [Planing Hull Assistant figures](#)¹⁰².

Note that you may choose which parameter to use to define the shape of the bottom moving forward from the transom; *Constant Transom-Mid Deadrise* (the transom deadrise angle will continue to midships), *Mid Deadrise* (you specify the deadrise angle at midships), or *Bottom Rocker* (you specify the angle of the keel in profile view, which defines the deadrise angles).





See also:

[Hull Design](#)¹⁷⁴

6.4 Hull Modeling

This tutorial shows you the basics of modifying a hull surface in Orca3D using the Orca3D control points. For more detailed instructions and background information see the [Hull Design](#)¹⁷⁴ section.

Hull modeling in Orca3D is accomplished using Rhino's NURBS surfaces, and the surfaces are modified by moving the control points. While you can do this using Rhino's control points, Orca3D has custom control points that provide more functionality: as they are moved, the sections are updated in real-time, and if you've checked the "Real-Time Hydrostatics" box in [Define Design Condition](#)¹³², the hydrostatics will update in real-time as well.

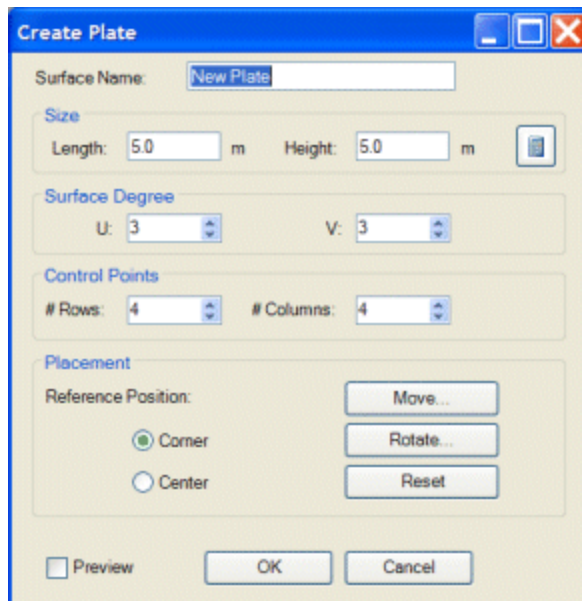
Orca3D hull modeling tools include:

- [Hull Assistants](#)⁹⁸
- [Starting](#)¹²¹ from a "flat plate" [NURBS](#) Surface
- [Section Definition](#)¹²⁶
- [Design Hydrostatics](#)¹³²
- [Orca Control Points](#)¹²¹

- [Orca3D Move Control](#)^[122]
- [Real-Time Hydrostatics](#)^[122]
- [Corner Wrap](#)^[213] tool (to create a smooth forefoot, for example)
- [Lines Plans](#)^[216]
- [Exporting Curves](#)^[227] for other programs (IDF and PIAS)

Starting from a "flat plate" NURBS Surface



Often a hull design is begun using an existing model, importing a hull from another program, or one of the Hull Assistants. But sometimes it is easiest to begin with a "flat plate" of [NURBS](#) surface, and then "sculpt" that flat surface into the desired shape. While Rhino has a function for creating a rectangular surface, it does not give you control over the degree and number of rows and columns. The OrcaCreatePlate command (in the Hull Design menu) provides this control, as shown in the dialog:



The plate will be created in the plane of the active viewport, and it may be moved or rotated. The Length and Height may be entered numerically, or graphically by clicking on the icon to the right of the values.

Orca Control Points

Toolbar	
Menu	Orca3D > Hull Design > Orca3D Control Points On
Command	OrcaPointsOn

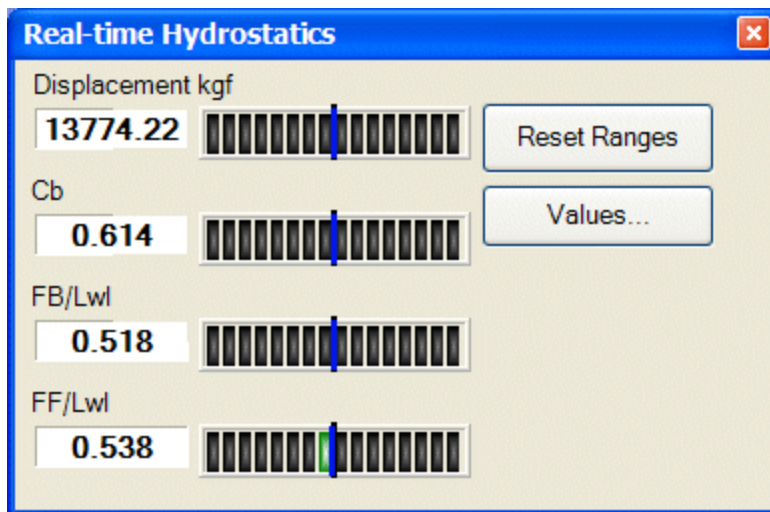
1. Start the command from the toolbar, menu, or command line.
2. Select the surface(s) you wish to edit, and hit Enter.
3. The control points for the surface(s) will be shown. Orca control points, and the lines that connect them, are drawn differently than the standard Rhino control points. You may control the color of the lines in the control polygon in the Orca Properties dialog (). By default, control lines in the U direction (longitudinal, in general) are drawn in cyan, and the V direction (transverse, in general) are drawn in green.
4. Move the control points just as you would the Rhino control points. If you have defined Orca Sections, they will update in real-time (remember that the smoothness of the real-time curves is controlled by the smoothness of the Orca Mesh, which can be adjusted in Orca Properties). If you have checked the [Real-Time Hydrostatics](#) ^[122] box in the [Define Design Condition](#) ^[132] dialog, you will also see a window showing the hydrostatics data updating.
5. To simplify the process of moving control points in the Perspective viewports, Orca3D implements Edit Planes. These are constraint planes, so that as you move a control point in the Perspective viewport, it will move parallel to the Edit Plane. For example, if the Edit Plane is chosen to be Station, the control points will move transversely and vertically, but not longitudinally. The Edit Planes are available from the toolbar () , or with the command OrcaEditPlane.

Orca3D Move Control

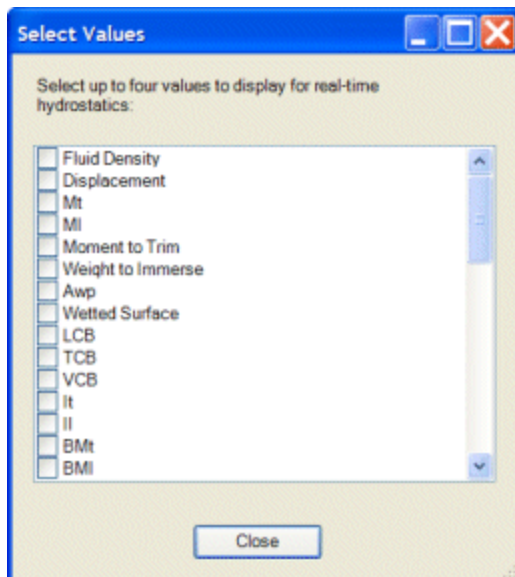
When hulls are modeled by the direct manipulation of control points, it's important to be able to easily and quickly drag the control points to "sculpt" the shape of the hull. But it is also important to be able to very precisely place the control points, or make "fine-tuning" adjustments to tweak the hull shape. The [Orca3D Move Control](#) ^[197] allows you to easily enter the coordinates of an [Orca Control Point](#) ^[121] (it will not work on standard Rhino control points) or other objects in your model. Multiple Orca Control points and/or objects can be moved together, and the coordinates may either be Absolute (World) or Relative. To make it easier to precisely set angles (such as a deadrise angle), you may also use a Polar coordinate system.

Real-Time Hydrostatics

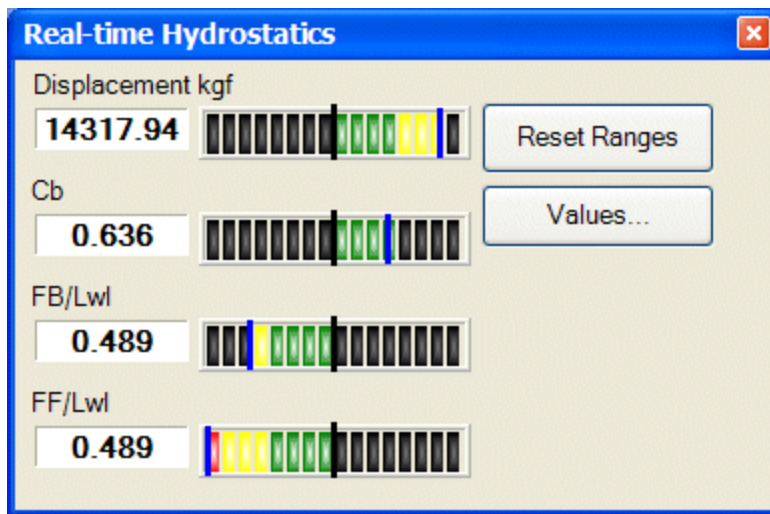
As Orca control points are moved, the program can compute and display various hydrostatic properties of your model, using the [Design Hydrostatics](#) ^[132] condition (which specifies the surface(s) to be included, as well as the flotation condition). To enable this function, open the Design Hydrostatics dialog (**Orca3D > Stability > Define Design Condition**), and check the Real-Time Hydrostatics box. A window showing various values will be displayed.



The values to be shown (up to 4) may be chosen by clicking on the Values button.



As the hull is modified and the values change, the slider bar will move up and down to show the trend, and colored "LED's" are displayed to show how far the value is from the original value. The LED's will change from green to yellow when the value moves 2.5% from the original, and red at 5%. The sliders can be reset at any time to the current value by clicking on the "Reset Ranges" button.

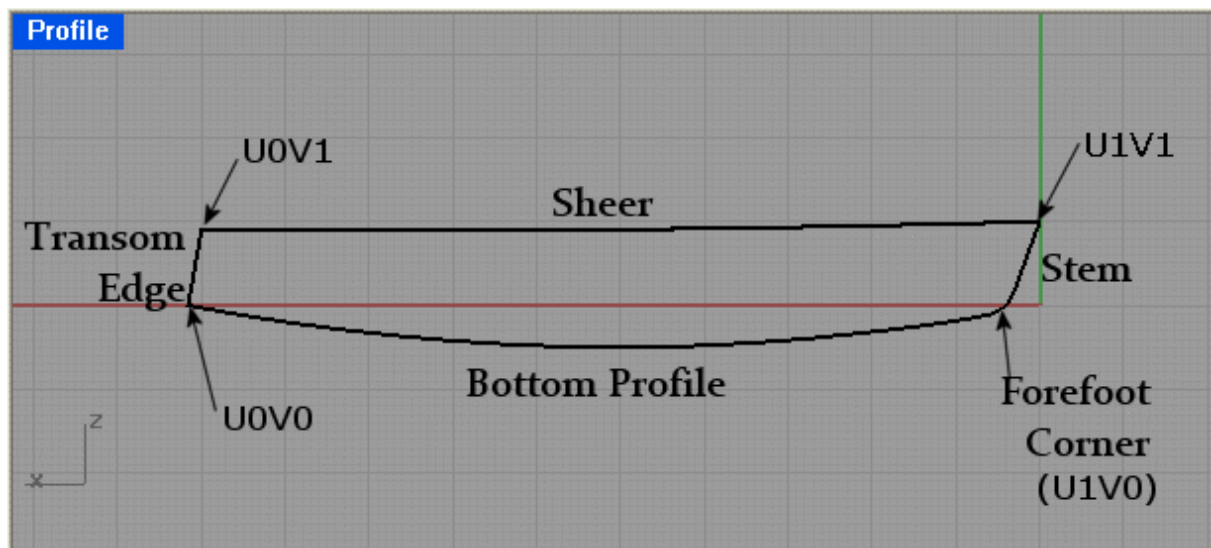


To turn off Real-time Hydrostatics, go back to the Define Design Condition dialog, and de-select the Real Time Hydrostatics check box.

Note: If your hull has been trimmed and you are moving control points that affect the surface in the region of the trimming, the resulting real-time hydrostatics will not be correct. In order to compute the correct hydrostatics, you will first need to re-trim the surface.

Corner Wrap

One of the characteristics of NURBS surfaces is that they fundamentally have four corners and four edges. As they are applied to hull design, these four edges usually correspond to the sheer line, the stem, the bottom profile, and the transom corner. The corners are the intersections of these four edges. Generally, the corners are discontinuities, with the exception of the stem-bottom profile corner (forefoot). Here, it's usually the case that a smooth transition is desired, with at least slope continuity, but preferably with curvature continuity (which requires a surface that is cubic in both the U and V directions).



Orca3D provides a function to precisely place the corner control point to create this smooth transition. To create the smooth transition, select the **Corner Wrap** command from the **Orca3D > Hull Design** menu. The first prompt asks which surface the corner wrap should be applied to, and the second prompt allows you to select which of the four corners should be smoothly wrapped:

Select surface for applying corner wrap.:

Select the corners to wrap (1st=Don't_Apply 2nd=Don't_Apply 3rd=Don't_Apply 4th=Don't_Apply EnableControlPoints): |

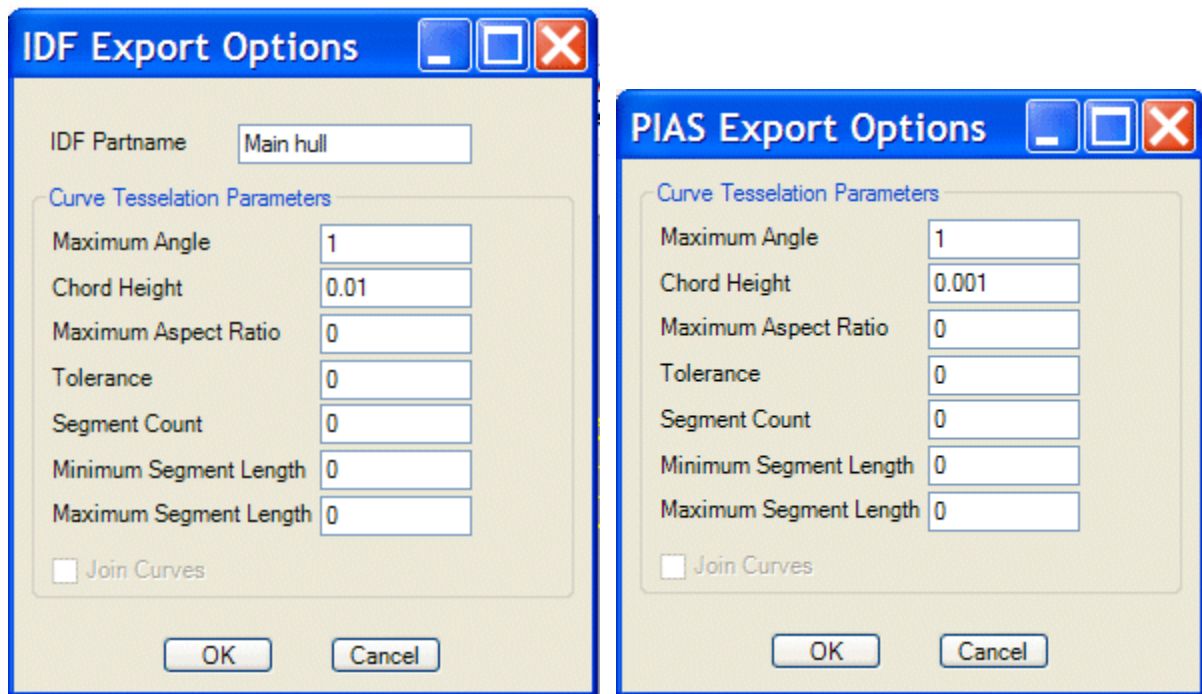
By clicking on the marker on any corner of the surface, its corresponding Corner will toggle between "Apply and "Don't Apply," and a preview of the wrapped corner will be shown. Once you have selected the desired corner(s), hit Enter to complete the command. The corner control point will now be precisely located to create continuity at that corner. Note that if you later move the corner point or the two edge points on either side of it (on a cubic surface), you will need to use the Corner Wrap command again to create the curvature continuity at that corner.

Lines Plans

Using Rhino's Page Layout capability, a traditional three-view lines plan can be created instantly. All Orca sections are displayed on the lines plan. To create the lines plan, click on the Lines Plan toolbar icon, or select **Lines Plan** from the **Orca3D > Hull Design** menu.

Exporting Curves

Orca3d can export curves to either IDF or PIAS format, for use in other programs. To export in either format, select the curves to be exported, and then select Export Curves from the **Orca3D > Hull Design** menu. In the Export Filename dialog, select the file type, enter a file name, and click on Save. A dialog will be shown that allows for controlling the smoothness of the curves:



See also:

[Hull Design](#) ¹⁷⁴

6.5 Sections

This tutorial shows you the basics of creating sections through your model in Orca3D. For more detailed instructions and background information see the [Sections](#) ²³⁶ section.

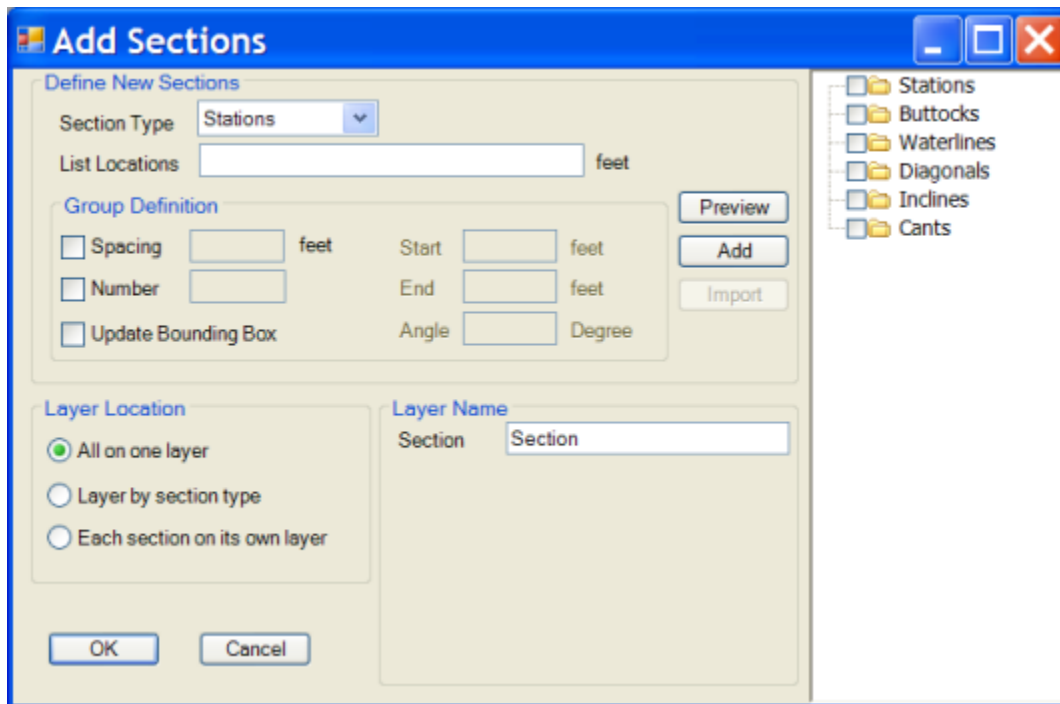
Orca3D uses Rhino's contour command to compute the sections, but they are treated differently than standard Rhino curves. Orca3D can control whether the section curves are displayed at any given time, can update them in real-time as the hull surface is modified, uses them for computation of the sectional area curve, prismatic and maximum section coefficient, and will output them to a lines plan.

The smoothness of the section curves is controlled by Rhino's tolerance values (File/Properties/Units). However, real-time section smoothness, during the actual editing process, is controlled by the Orca3D mesh parameters, which can be set in the [meshing tab of](#)


[Orca3D Properties](#) ⁸⁷ (.

Toolbar	
Menu	Orca3D > Hull Design > Sections
Command	OrcaSections

1. Start the command with the toolbar icon, menu selection, or keyboard command.
2. Select the surface(s) to be included
3. The Add Sections dialog will appear:



4. Select the type of Section that you want to add to the list (Stations, Buttocks, etc.)
5. Define the Section locations by List (plane constant), and/or Spacing or Number. Checking "Update Bounding Box" will automatically fill in the minimum and maximum dimensions of the selected surface(s) in the direction perpendicular to the Section type in the Start and End fields. Note that if the Start value is less than the End value, the Spacing must be greater than 0, and if the Start is greater than the End, the Spacing must be less than 0. See [Defining Locations](#)^[239] for more detail.
6. Select the Layer location for the Sections.
7. Click Add to add your Sections to the Sections list. The list of Section locations will be shown in the Section tree.
8. Click Preview to see planes in the model representing the Section locations.


9. Repeat for other Section types.
10. You may turn off visibility for one or more Sections, using the check boxes in the tree.
11. You may right click on any Section in the tree to remove it, preview it, or change its color.
12. Right-click on a node (for example, "Stations" to operate on all of the sections of that type.
13. Click on OK. The Sections will be computed on the selected surface(s). If this surface is edited using the Orca control points, they will be updated in real-time.
14. The calculation and visibility of the Sections may be temporarily turned off, using the **OrcaShowSection** command, or the icon ()

See also:

[Sections](#) ²³⁶

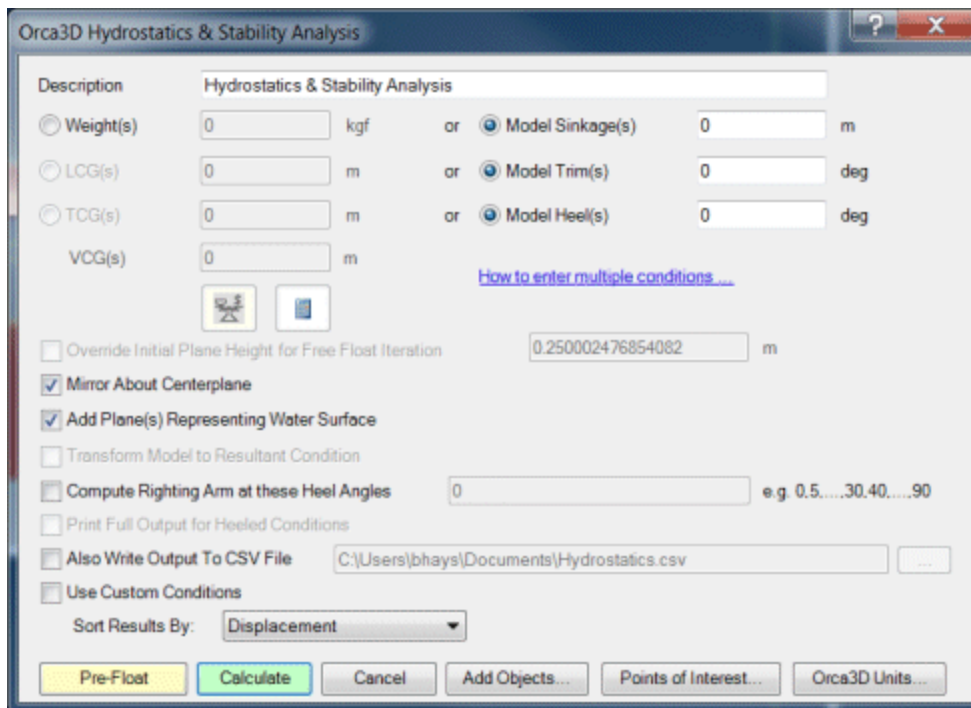
6.6 Hydrostatics & Stability

This tutorial shows you the basics of computing hydrostatics and stability in any condition in Orca3D. For more detailed instructions and background information see the [Hydrostatics & Stability](#) ²⁴⁷ section.

Toolbar	
Menu	Orca3D > Stability > Compute Hydrostatics & Stability
Command	OrcaHydrostatics

In Orca3D, you may compute hydrostatics and stability at a range of waterplanes, or one or more combinations of displacement and center of gravity.

1. Start the command through the menu, toolbar, or command line.
2. Select the surface(s) to be included. Be careful to only select surfaces that could potentially be wet. Do not select interior surfaces, only surfaces that are part of the "displacer." Hit Enter.
3. The following dialog will appear.



The image shows the 'Orca3D Hydrostatics & Stability Analysis' dialog box. It has a title bar with a question mark and a close button. The main area is divided into two columns. The left column has radio buttons for 'Weight(s)', 'LCG(s)', 'TCG(s)', and 'VCG(s)', each followed by a text input field set to '0' and a unit label (kgf or m). The right column has radio buttons for 'Model Sinkage(s)', 'Model Trim(s)', and 'Model Heel(s)', each followed by a text input field set to '0' and a unit label (m or deg). Below these is a link 'How to enter multiple conditions...'. There are two small icons below the input fields. Further down are several checkboxes: 'Override Initial Plane Height for Free Float Iteration' (unchecked, with a text field '0.250002476854082' and unit 'm'), 'Mirror About Centerplane' (checked), 'Add Plane(s) Representing Water Surface' (checked), 'Transform Model to Resultant Condition' (unchecked), 'Compute Righting Arm at these Heel Angles' (unchecked, with a text field '0' and example 'e.g. 0.5.....30.40.....90'), 'Print Full Output for Heeled Conditions' (unchecked), 'Also Write Output To CSV File' (unchecked, with a text field 'C:\Users\bhays\Documents\Hydrostatics.csv' and a browse button), and 'Use Custom Conditions' (unchecked). At the bottom is a 'Sort Results By:' dropdown menu set to 'Displacement'. The bottom of the dialog has a row of buttons: 'Pre-Float' (yellow), 'Calculate' (green), 'Cancel' (grey), 'Add Objects...' (grey), 'Points of Interest...' (grey), and 'Orca3D Units...' (grey).

Enter the Model Sinkage, Trim, and Heel, or the Weight (displacement) and a combination of LCG/Trim and TCG/Heel.

Notes on Entering Multiple Conditions

In all of the fields in the Hydrostatics & Stability dialog (except "Override Initial Plane Height"), you may enter a list of values, separated by commas or ellipses (...). For example, a list of Model Sinkages might be

1,2,3,4,5

As a shorthand, you may also enter the following to get the same list:

1,2,...,5

The spacing implied by the two numbers before the ellipses will be used until the number after the ellipses is reached or exceeded (*note the commas before and after the ellipses*). Multiple spacings may be entered, as in the following example for heel angles:

0,5,...,30,40,...,90,120,...,180

This is equivalent to entering:

0,5,10,15,20,25,30,40,50,60,70,80,90,120,150,180.

The matrix of flotation conditions that will be computed is created from all of the combinations of the various entries. For example, if you enter:

Model Sinkage: 1, 2, 3

Model Trim: 1.5, 2.5

Model Heel: 5, 10

12 flotation conditions will result.

If you have chosen the Weight option (rather than Model Sinkage), you may also click on the "Weight/Cost" icon, and the total weight and center of gravity will be computed from the objects in the model that have weight properties, and the values filled in to the Weight, LCG, TCG, and VCG fields (this option requires that you have Orca3D Level 2, which includes the Weight/Cost Tracking module). Note that these values represent only what is explicitly modeled (it does not double the weight when you check Mirror About Centerplane, for example), and only the objects that have Weight properties assigned to them. If you have only modeled half of the hull, you should double the Weight value, and (presumably) move the TCG to 0. Note: this is not a permanent link. You must click the icon each time you wish

the values to be updated.

You can manually compute the overall weight and CG of a number of items using the Calculator icon. For example, if you know the weight and CG of the lightship, crew & effects, and fuel, you can enter each of them individually, and the sum will be entered into the appropriate fields in the Hydrostatics dialog. This data is stored with the Rhino model.

The Orca3D Weight Calculator dialog box contains a table with the following data:

Name	Weight (kgf)	LCG (m)	TCG (m)	VCG (m)
LightShip	12500	6.5	0	0.75
Crew & Effects	500	6.2	0	1
Fuel	200	7.3	0	0.25
New Item	0	0	0	0

Below the table, the Totals are displayed:

	Weight (kgf)	LCG (m)	TCG (m)	VCG (m)
Totals	13200.000	6.501	0.000	0.752

Buttons at the bottom include OK, Cancel, Add Item, and Delete Item(s).

4. If your model represents only half of the vessel, be sure to check the box entitled "Mirror About Centerplane."

5. If you'd like to see a planar surface that represents the waterplane in the resulting condition, check "Add Plane(s) Representing Water Surface." The centers of buoyancy and flotation will be marked, and a sectional area curve will be displayed as well if [stations](#)²³⁷ have been defined. The scale and color of this curve may be set in Orca3D Document Properties, in the [Hydrostatics tab](#)⁸⁶.

6. The model can be moved so that the Z=0 plane represents the waterplane. If you'd like to transform the model, check the "Transform Model to Resultant Condition" box. *Note that output results (such as VCB) are reported in the coordinate system of the original model orientation.*

7. If you want to see Righting Arm data, check the "Compute Righting Arm at..." box, and enter a list of heel angles. **Note that you will now also have to enter the VCG.** The value of the heel angles must be between -180 to 180 degrees. For example:

0,10,...,180 will compute every 10 degrees from 0 to 180

or

0,-20,...,-60 will compute every 20 degrees from 0 to -60

or

-150,-140,...,0,5,...,60 will compute every 10 degrees from -150 to 0, then every 5 degrees from 0 to 60

8. If you want full output for each heel angle, check the "Print Full Output..." box. This may result in a very large report.

9. If you also want output written to a comma-separated-value (CSV) format (suitable for import into Excel, or parsing with another program), check "Also Write Output to CSV File," and enter the path and filename. The format of this file is self-documenting.

10. If you need to add surfaces to those you originally selected, click on "Add Objects," and select them. Hit Enter, and you will return to the dialog.
11. Click on OK. The results will be computed and displayed in a new window. Use the controls at the top of the report to navigate to the various pages in the report. Note that the report can be printed, or saved in either PDF or Excel format.

Overriding the Initial Plane for Free Float Iteration

When the weight and/or center of gravity is entered, Orca3D does an iterative process to arrive at the equilibrium flotation condition. As a starting guess, a flotation plane at the mid-height of the selected geometry is used, with zero trim and heel. Sometimes this isn't a good guess because, for example, at this point the waterplane is vastly different than it is at the true equilibrium condition. For example, if your sailboat model includes the mast, and you have included that geometry in your selection, the initial plane will be somewhere up the mast, with a very small waterplane (and resulting in a very large displacement). This can sometimes cause Orca3D's solver to have difficulty converging in such a case. To avoid this, enter a different value for the Initial Plane that is closer to the final equilibrium height.

See also:



[Hydrostatics & Stability](#)^[247]

6.7 Design Hydrostatics

This tutorial shows you the basics of computing hydrostatics in the "Design" condition in Orca3D. For more detailed instructions and background information on Orca3D Hydrostatics in general, see the [Hydrostatics & Stability](#)^[247] section.

Note: Orca3D computes most of the hydrostatics parameters from the surface mesh, not in the traditional manner of integrating stations (stations are used for the sectional area curve, and the prismatic and maximum section coefficients). In general, this leads to more accurate results, and avoids the possibility of missing or mistreating features in the hull surface, such as the end of a hull skeg. The accuracy of the calculations, therefore, depends on the smoothness of the surface mesh (this is true in Rhino for other things; for example the curvature maps depend on the smoothness of the analysis mesh). To adjust the

smoothness of the Orca3D mesh, use the [OrcaProperties](#)^[77] command, or the icon () , and set the values in the [Orca Mesh Parameters](#)^[88] section.

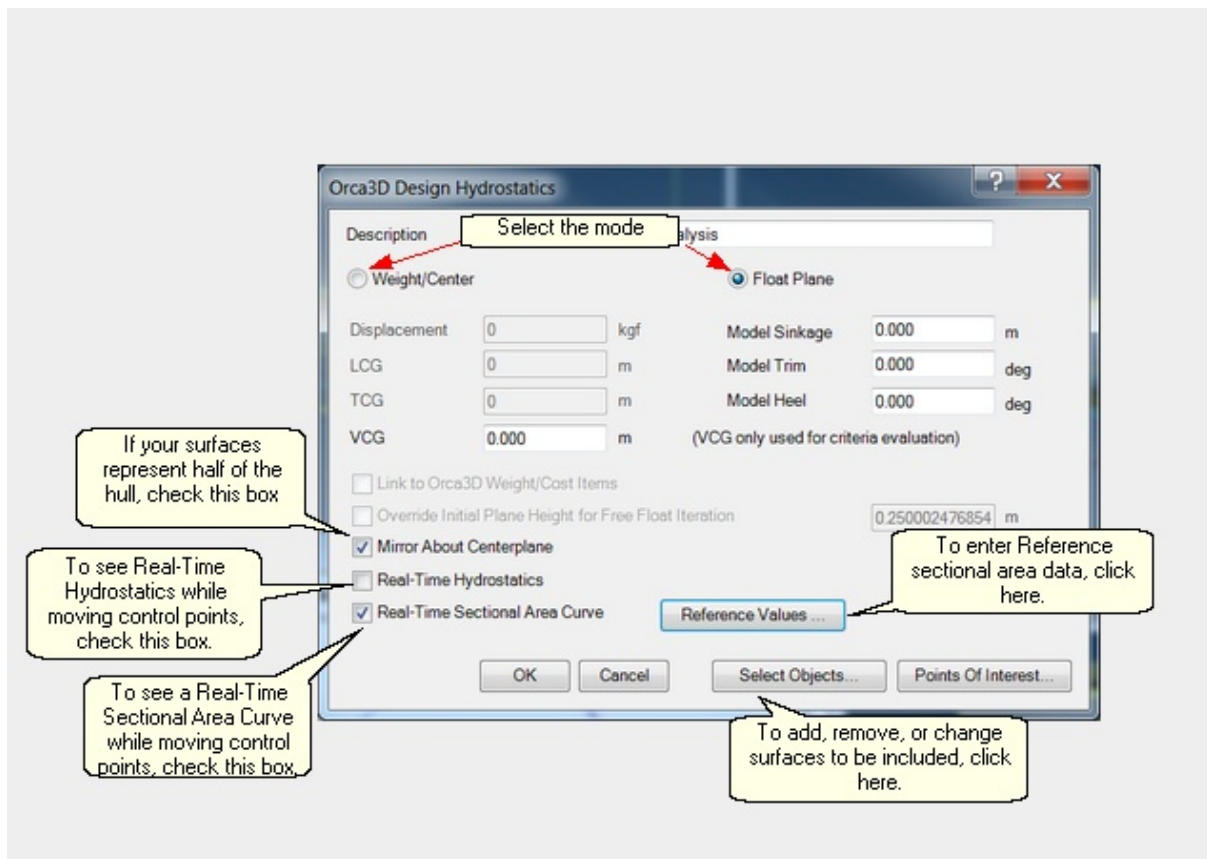
Toolbar	 
Menu	Orca3D > Stability > Define Design Condition Orca3D > Stability > Compute Design Hydrostatics
Command	OrcaDefineDesignSimulation OrcaPlayStabilitySimulation

Orca3D can compute hydrostatics and stability in various combinations of waterplanes/ displacement and center of gravity/heel/trim, with a range of heel angles. However, while you are fairing a hull, you are usually just interested in the hydrostatics at the "design waterline," or at a particular displacement/center of gravity, without needing to go through entering values in a dialog box each time you want to see the calculations.

To simplify the process, Orca3D has a special Hydrostatics and Stability condition called the "Design" condition. The intent is to define the Design condition once, and then as you create and modify the hull, you can compute hydrostatics and stability at that condition with a single button click. This saves having to go through the dialog to define the condition each time you wish to compute the hydrostatics. Also, the Design Condition can be used as the condition to evaluate in Planing or Displacement resistance calculations.

To define the Design condition:

1. Select **Define Design Condition** from the **Orca3D > Stability** menu, or select the Define Design Condition icon. The following dialog will appear:



2. Click on the Select Objects button, then select the surface(s) to be included in the Design Condition.
3. Select which mode you want: Weight/Center, or Flotation Plane.
4. If you wish the weight and center of gravity to be computed from the Orca Weight/Cost properties that you have assigned to objects in your model, check "Link to Orca3D Weight/Cost Items." When this box is checked, before the Design Hydrostatics are computed each time, the total weight and center of gravity will be computed from those objects in the model which have weight properties assigned to them. Note that this is only appropriate if you have modeled both sides of the model, and assigned enough weight items to account for the entire weight of the vessel. *Note: you cannot use this option in conjunction with Real-Time Hydrostatics.*
5. If your surface model represents just one-half of the vessel, check "Mirror About Centerplane"
6. If you want to see hydrostatic values in real-time as you edit the hull, check the "Real-Time Hydrostatics" box (cannot be used in conjunction with "Link to Orca3D Weight/Cost Items").
7. If you want to see the Sectional Area curve in real-time as you edit the hull, check the "Real-Time Sectional Area curve box. If you'd like Reference Values to be overlaid on the Sectional Area curve (target values for the curve, for example), click the Reference Values button.

Important; you will need to re-define your Design Condition when your hull model has fundamentally changed, e.g. you split, add, or delete a surface.

Note that if you had pre-selected one or more surfaces before starting Define Design Condition, the following will occur:



- If this is the first time that you've defined the Design Condition for this model, those surfaces will be used as the geometry for the Design Condition.
- If the Design Condition has been previously defined, the selection will be changed to the surface(s) that are already defined in the Design Condition.

To change the surface(s) that are used in the Design Condition, click on Select Objects. Everything will become unselected, and you should now select the surface(s) to be included in the Design Condition, and hit Enter.

Overriding the Initial Plane for Free Float Iteration

When the weight and/or center of gravity is entered, Orca3D does an iterative process to arrive at the equilibrium flotation condition. As a starting guess, a flotation plane at the mid-height of the selected geometry is used, with zero trim and heel. Sometimes this isn't a good guess, because, for example, at this point the waterplane is vastly different than it is at the true equilibrium condition. For example, if your sailboat model includes the mast, and you have included that geometry in your selection, the initial plane will be somewhere up the mast, with a very small waterplane (and resulting in a very large displacement). It's more difficult (and slower) for Orca3D's solver to converge in such a case. To avoid this, enter a different value for the Initial Plane that is closer to the final equilibrium height.

To compute Design hydrostatics:

1. Be sure that you have defined the Design condition, using the steps above. You only need to do that once, unless you wish to change the surface(s) to be included, or change the Design condition. *Note that you should not select any geometry; the surface(s) that are used in computing the Design Condition are defined when you define the Design Condition.*
2. Select **Compute Design Hydrostatics** from the **Orca3D > Stability** menu, click on the () icon on the toolbar (the icon is on a flyout toolbar with the Hydrostatics & Stability icon), or type the command OrcaPlayStabilitySimulation.
3. After a moment, the hydrostatics report will be displayed.
4. If you checked the "[Real-Time Hydrostatics](#) " box, the hydrostatics will be displayed in a dockable control, as you modify the surface with the Orca3D control points.

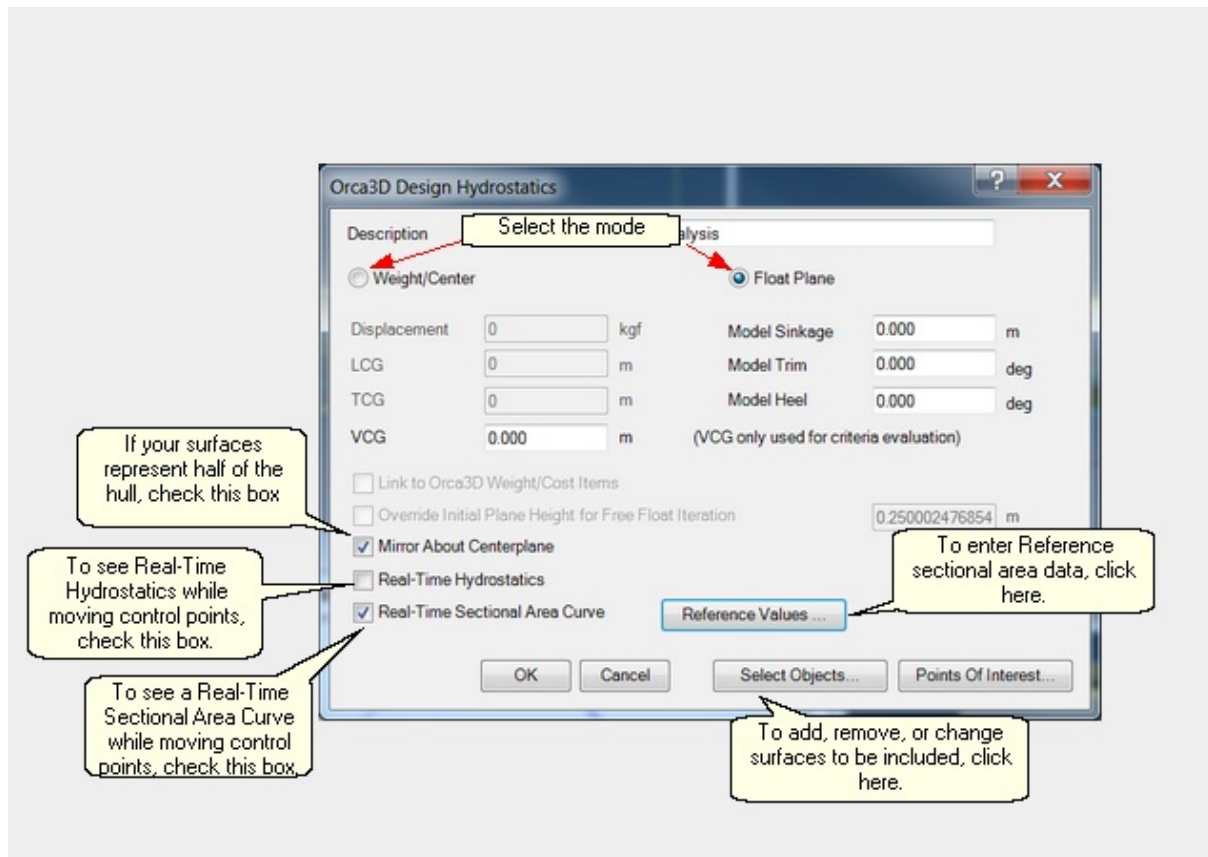
See also:

[Hydrostatics & Stability](#) 

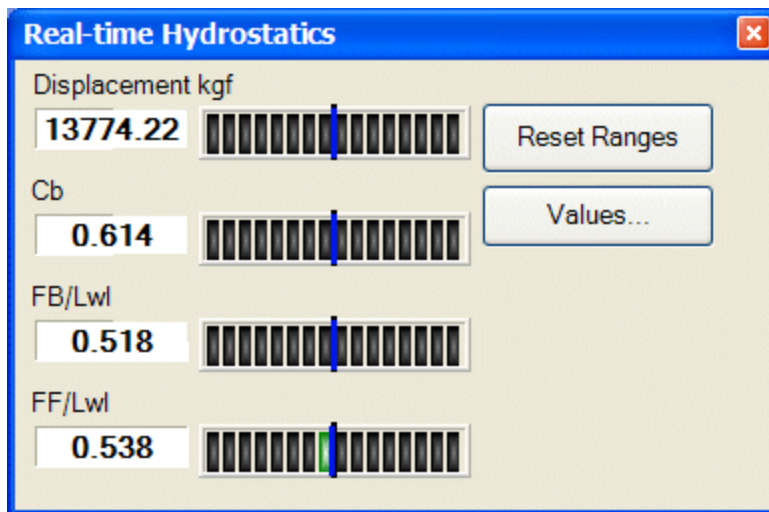
6.8 Real-Time Hydrostatics

Real-Time Hydrostatics

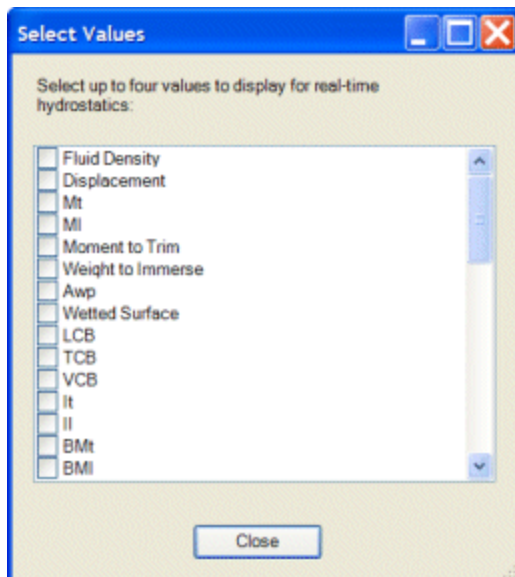
As Orca control points are moved, the program can compute and display various hydrostatic properties of your model, using the [Design Hydrostatics](#)^[132] condition (which specifies the surface(s) to be included, as well as the flotation condition). To enable this function, open the Design Hydrostatics dialog (**Orca3D > Stability > Define Design Condition**), define your flotation condition (i.e., Weight/Center or Float Plane), select Mirror About Centerplane if your model is a half-hull, and check the Real-Time Hydrostatics box. Click on OK.



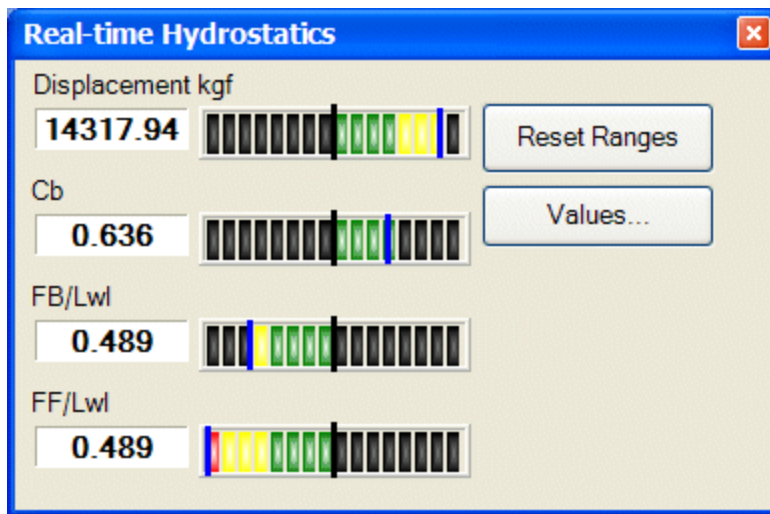
A window showing various values will be displayed.



The values to be shown (up to 4) may be chosen by clicking on the Values button.



As the hull is modified and the values change, the slider bar will move up and down to show the trend, and colored "LED's" are displayed to show how far the value is from the original value. The LED's will change from green to yellow when the value moves 2.5% from the original, and red at 5%. The sliders can be reset at any time to the current value by clicking on the "Reset Ranges" button.



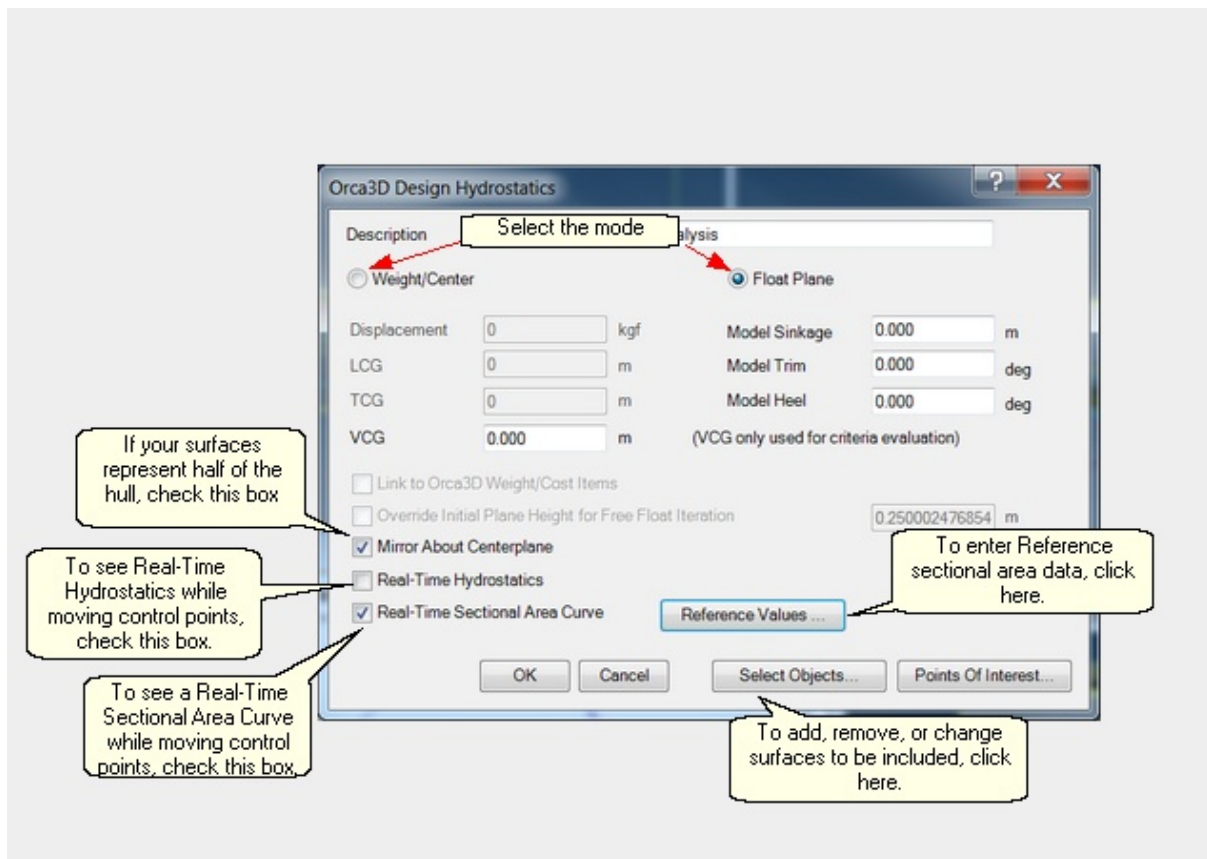
To turn off Real-time Hydrostatics, go back to the Define Design Condition dialog, and de-select the Real Time Hydrostatics check box.

Note: If your hull has been trimmed and you are moving control points that affect the surface in the region of the trimming, the resulting real-time hydrostatics will not be correct. In order to compute the correct hydrostatics, you will first need to re-trim the surface.

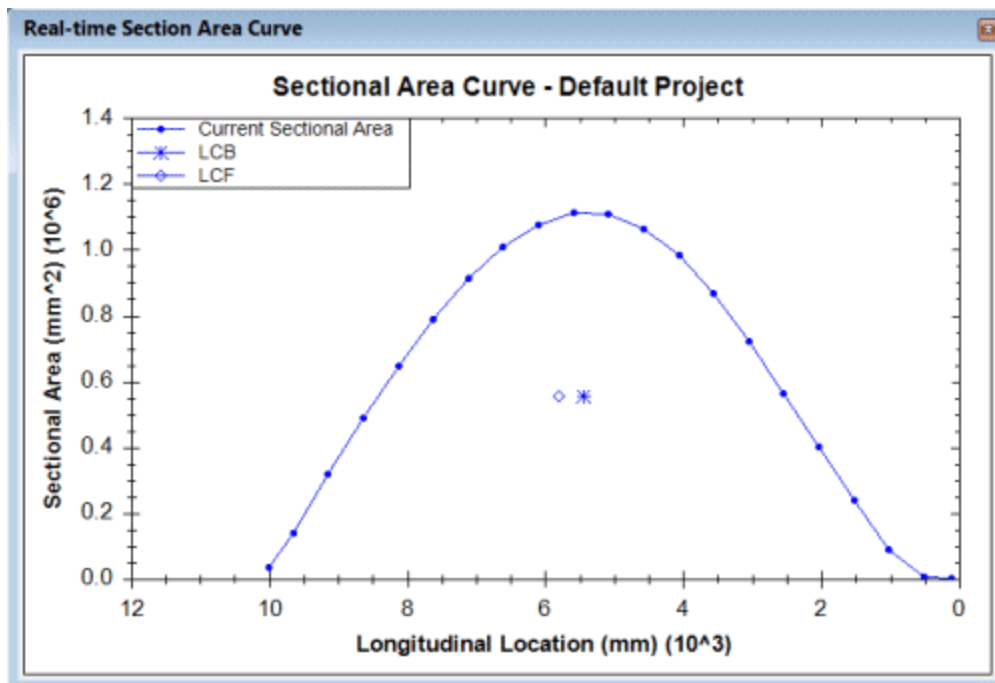
6.9 Real-Time Sectional Area Curve

Real-Time Sectional Area Curve (SAC)

As Orca control points are moved, the program can compute and display a Sectional Area Curve (SAC) in real-time, using the [Design Hydrostatics](#)^[132] condition (which specifies the surface(s) to be included, as well as the flotation condition). To enable this function, open the Design Hydrostatics dialog (**Orca3D > Stability > Define Design Condition**), define your flotation condition (i.e., Weight/Center or Float Plane), select Mirror About Centerplane if your model is a half-hull, and check the Real-Time Sectional Area Curve box. Click on OK.



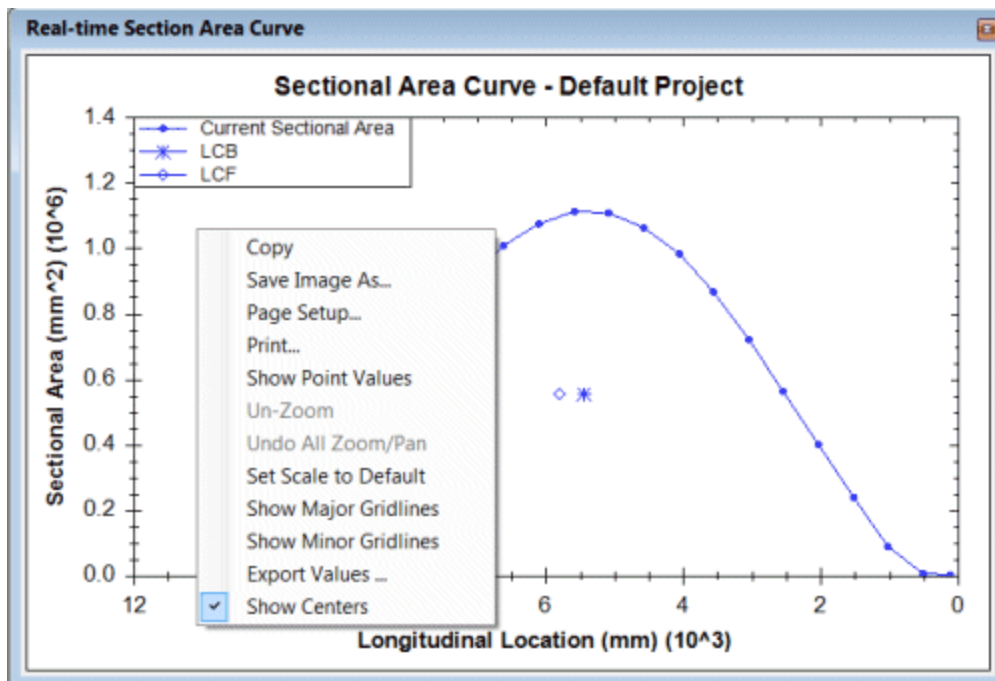
A window showing the SAC will be displayed, with data points at each of the station locations (which are defined in the [Sections](#)^[237] dialog). Reference Values can also be superimposed on the curve; this is a list of section locations and sections areas that might be used as target values as you edit the hull shape (see below for instructions on entering [Reference Values](#)^[141]).



Note that the horizontal scale is drawn according to your settings for the Model Orientation (General tab of the [Orca Properties](#) dialog) and the direction that the bow points (View tab of the [Orca Properties](#) dialog). In the example above, the Forward direction was defined as Negative X, and the bow is defined as pointing to the right.

The view can be zoomed by dragging a box with the left mouse button. If the box is a different aspect ratio than the current view, it will also cause a scaling change. Rolling the mouse wheel will zoom in and out, and clicking and holding the mouse wheel and dragging will pan the image.

As Orca control points are moved and the sections are updated, the SAC will update as well, including the location of the LCB and LCF, which are shown on the plot. Right-clicking on the plot will bring up a context menu, as shown below.

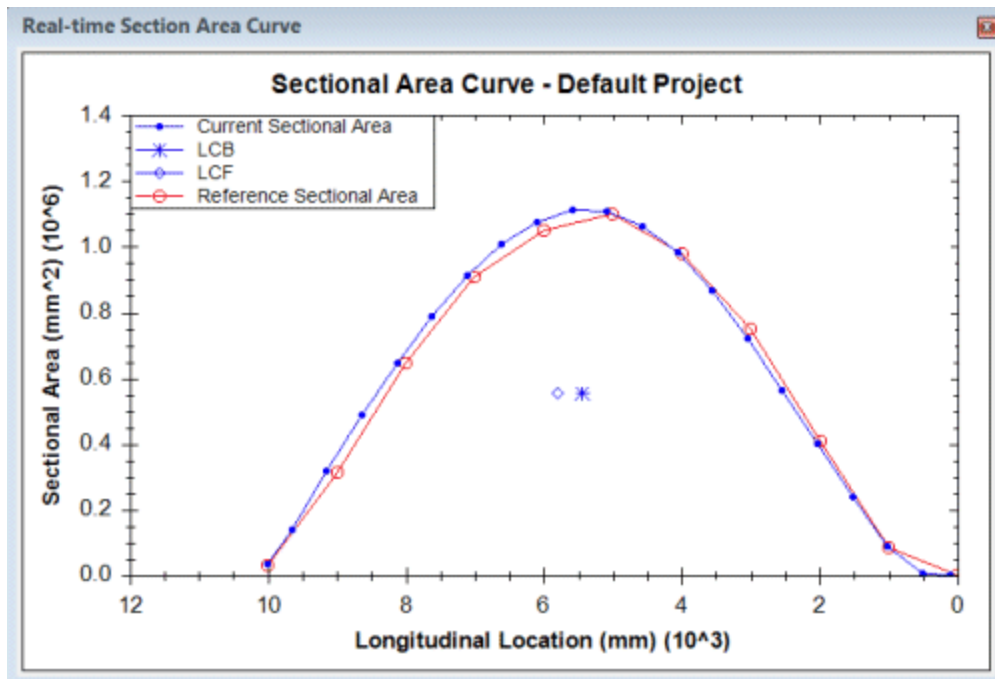


- **Copy:** Copies the image to the clipboard, so that you can paste it into other applications such as a document.
- **Save Image As...:** Saves the image in emf, png, gif, jpg, tif, or bmp format.
- **Page Setup:** Setup for printing.
- **Print:** Print to the system printer.
- **Show Point Values:** When this option is enabled, the values for each of the points will be shown when the cursor hovers over the point.
- **Un-Zoom:** Changes the zoom value back to the previous value.
- **Undo All Zoom/Pan:** Changes the zoom and pan back to the default values.
- **Set Scale to Default:** Changes the zoom, pan, and scale back to the default values.
- **Show Major/Minor Gridlines:** Toggles the major and minor gridlines on the X and Y axes.
- **Export Values:** Exports a csv file containing the section location, section area, and if defined, the reference data. This is easily read into Excel.
- **Show Centers:** Toggles the display of the LCB and LCF.

Reference Values

If you would like to have reference values superimposed on the plot, you can type the values in or import them from a csv file. The reference values could serve as target values as you

edit the hull.



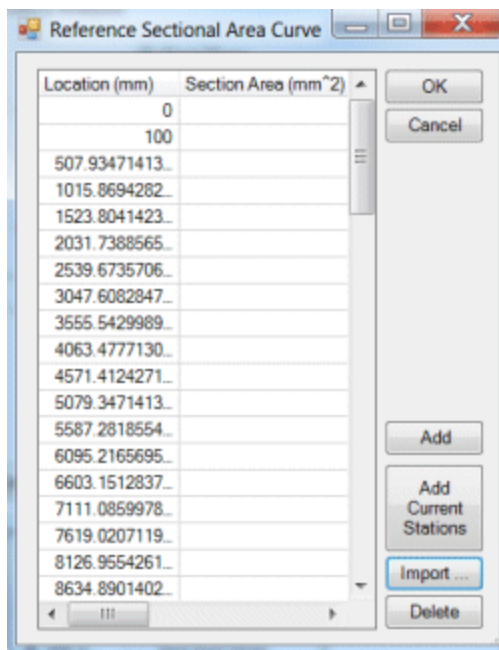
To enter the reference values, click on the Reference Values button on the Design Hydrostatics dialog. The Reference Sectional Area Curve dialog will be shown:

The figure shows the "Reference Sectional Area Curve" dialog box. It has a title bar with standard window controls. The main area is a table with two columns: "Location (mm)" and "Section Area (mm^2)". To the right of the table are buttons for "OK", "Cancel", "Add", "Add Current Stations", "Import...", and "Delete".

If you want to simply type in section location and sectional area values, click on Add, and enter the data. Click Add for each new row of data that you want to add.

If the section locations that you are using coincide with the section locations that you have defined in your model (in the [Define Sections](#) ²³⁷ dialog), you click on the Add Current

Stations button, and the section locations will be added. Now, just type in the reference sectional area values.



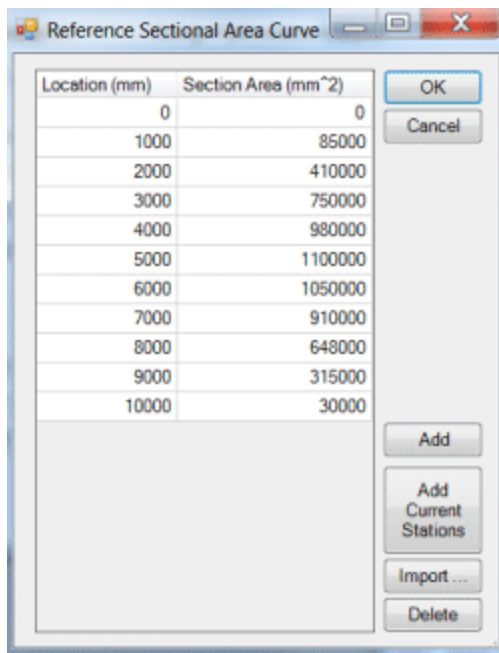
If you have the data in a csv file (exported from Excel, for example), it can be imported. The file should be a list of values, separated by commas (note that the section locations do not need to match the locations of the sections that you have defined in your model):

sectionlocation1,sectionarea1

sectionlocation2,sectionarea2

etc.

Save the file as a csv file, and then click the Import button. The data will be displayed as shown. Be sure that the units (both length and area) of your data match your [unit settings](#) ⁷⁸ in Rhino (length) and Orca3D (area).

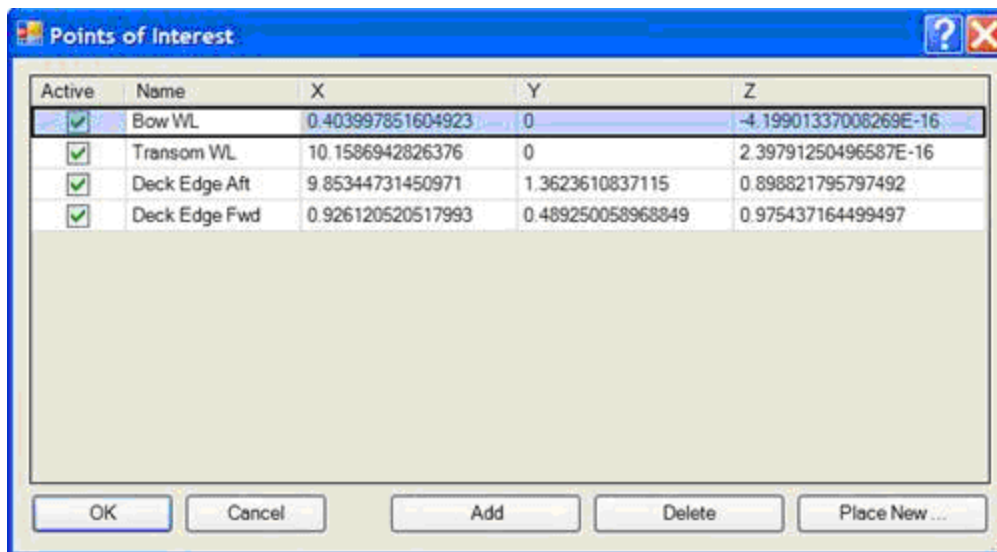


6.10 Points of Interest

Orca3D will track Points of Interest (POI) as the model heels, trims, and sinks during a hydrostatics and stability calculation, and report each POI's height above the flotation plane. This feature can be very useful for determining when a downflooding point, such as a vent or cockpit corner, will become submerged. A POI does not necessarily correspond with a physical "point" or object in the model; it is simply a location in space, specified by X, Y, and Z coordinates.

Toolbar	
Menu	Orca3D > Stability > Points of Interest
Command	OrcaPointsOfInterest

Start the OrcaPointsOfInterest command to display the dialog where they are defined:



To enter a new POI, click Add, then in the Name field enter a description of the POI. Enter the X, Y, and Z coordinates of the point. By checking the box in the Active column, you can determine whether the POI will be tracked and reported in the output. The POI's may be sorted by Name, X, Y, or Z by clicking on the column header.

If you wish to enter the coordinates of the POI by selecting a point in your model graphically, click on the "Place New..." button, and click on the appropriate location in your model. A new POI will be created in the list, and you will then be able to enter the Name for that point.

Depending on the orientation of the model and the direction of positive heel, you may wish to define the POI's on the negative side. For example, if positive X is aft, positive Y to starboard, and positive Z up, then positive heel angles will be to port. In this case, if you want to know when the POI's become submerged, enter negative Y values.

6.11 A Hull Design

This tutorial will show the process of creating a new hull shape using Orca3D's Hull Assistant and OrcaMove and then analyzing the fairness of the hull using Rhino's curvature functions, and finally producing a lines drawing and offset table.

For this example, we will create a 163 foot, single chined, monohull crew boat. The best starting point for this case will be to use the Planing Hull Assistant. This design assistant is intended for a double chined hull, but we can make it a single chine by setting the *Chine Width* to 0 feet.

The screenshot shows the 'Planing Hull Assistant' dialog box. At the top, there's a title bar with a question mark and a close button. Below it, a 'Description' field contains 'Default Planing Hull Assistant'. The main area has three tabs: 'Dimensions', 'Shape', and 'Angles'. The 'Dimensions' tab is active, showing a list of parameters with input fields and units. The 'Chine Width' field, which has the value '0', is highlighted with a red rectangle. Below the list, there are three checkboxes: 'Preview Hull' (checked), 'Preview Sections', and 'Preview Hydrostatics'. At the bottom, there are four buttons: 'Create Hull', 'Cancel', 'Save Settings', and 'Back To Hull Library'.

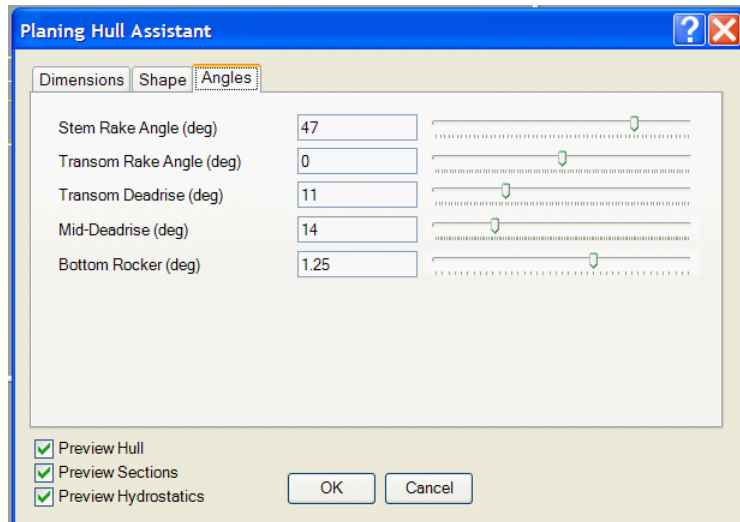
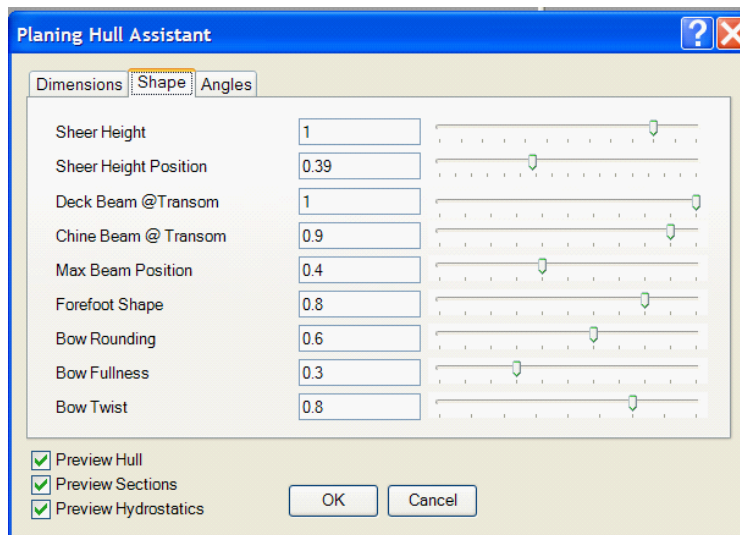
Parameter	Value	Unit
Length on Deck	163	ft
Beam on Deck	32	ft
Deck Height @Bow	7	ft
Deck Height @Transom	6.5	ft
Chine Height @Bow	2.5	ft
Keel Height @Transom	-4.1	ft
Chine Width	0	ft
Number of Net Columns	1	

To get a good feel for our design, we'll select the *Preview Hull* check box as well as *Preview Hydrostatics* in the Planing Hull Assistant dialog box. The *Preview Sections* check box allows you to see 21 evenly spaced stations in the previewed hull.

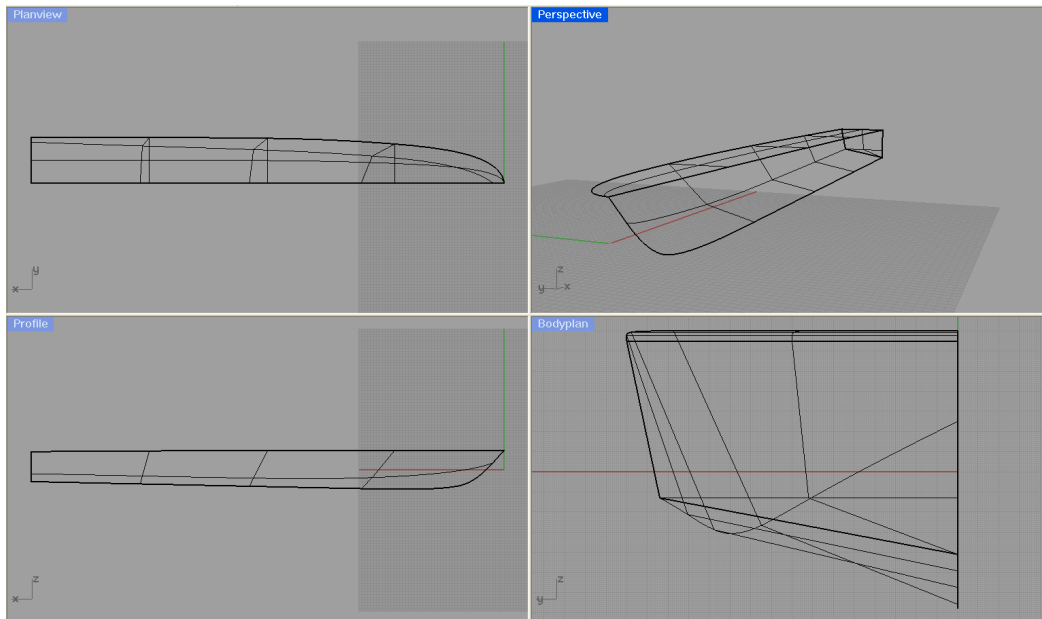
The dimensions of the vessel are set in the first tab of the Planing Hull Assistant. The deck, chine and transom heights are measured from the design waterline, which is the 0 Z-plane.


The preview hydrostatics are based on the waterline being located at the $Z = 0$ plane. If you wish to increase the draft of your vessel, you will want to increase the transom height. This height is essentially the draft aft of your vessel.

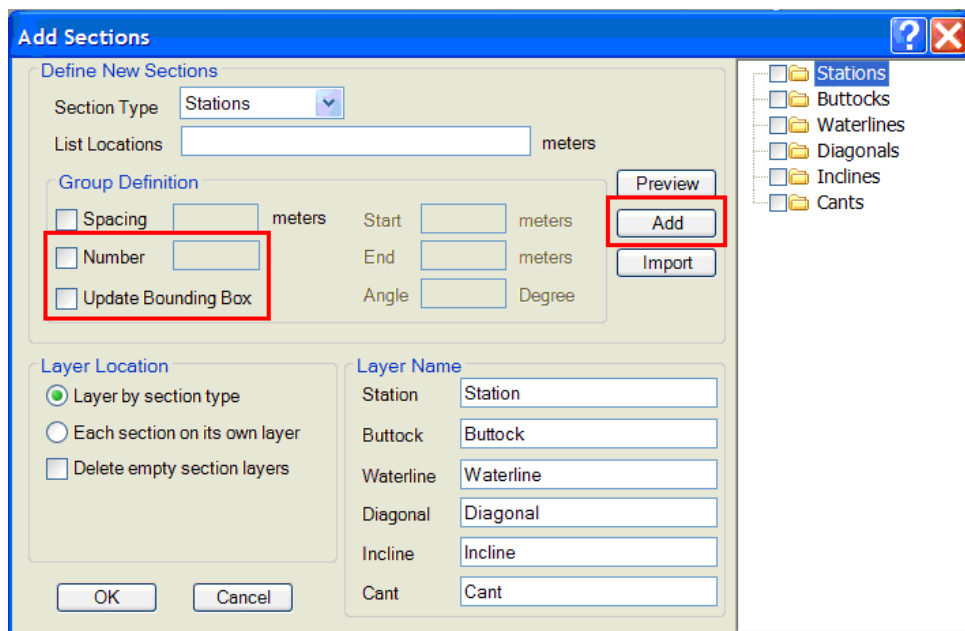
The Shape and Angles tabs allow you to further customize your hull design by defining several additional parameters.



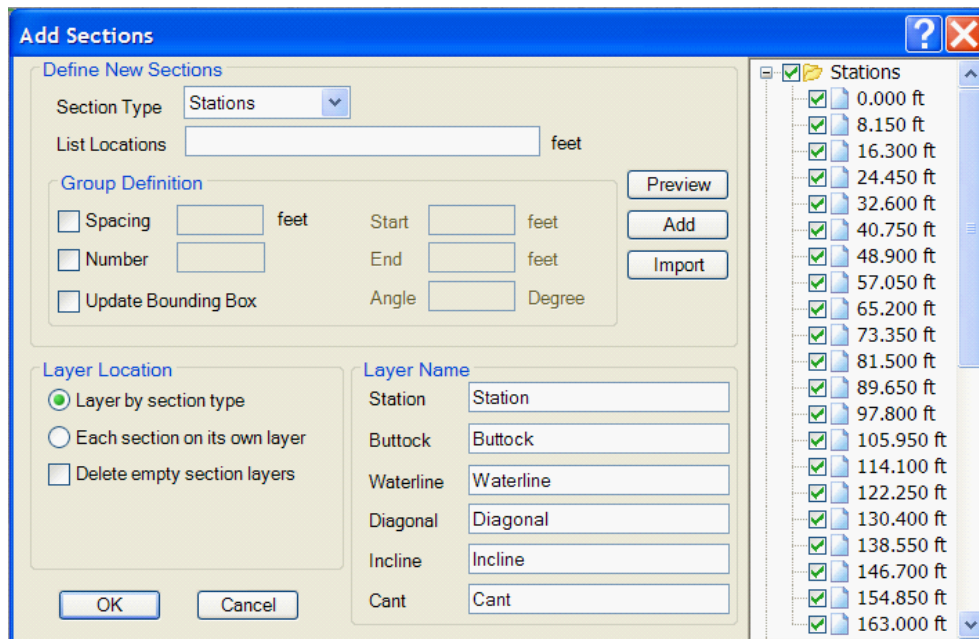
Our basic hull shape is now defined and ready to be finely tuned using OrcaMove.



First we will define 21 evenly spaced stations in the hull. To do this we will select all the surfaces of the hull and click the Orca3D Sections icon .

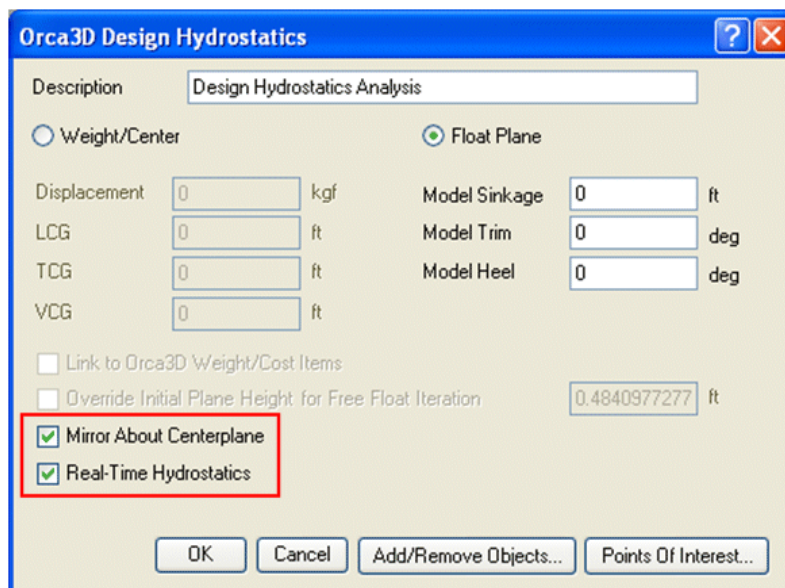


We can now add stations, buttocks, waterlines, diagonals, inclines, and cants. At this time, we will just add stations to our hull. The section type is already selected on *Stations*, so next we will click the *Update Bounding Box* checkbox. This will automatically update the *Start* and *End* text boxes with the geometric extents for the section type. We will then click the *Number* checkbox and type in "21" into the corresponding text box. We will then click the *Add* click box, and notice the stations are updated in the sections tree on the right hand side of the dialog box. Click OK to continue.




This same process can be used to add buttocks, waterlines, diagonals, inclines or cants.

Next we will define the Design Condition of our vessel. This will allow us to quickly calculate hydrostatics and stability reports for the design condition at the click of a button. With this defined, we can also see real-time hydrostatics while we are modifying the hull shape. To set the Design Condition, select the Orca3D menu -> Stability -> Define Design Condition. The prompt will ask you to select the surfaces to analyze. Select the hull surfaces and press Enter.



The Design Hydrostatics dialog opens and we can now define a description of this condition,


for example “design waterline.” There are two options to define the model orientation: providing the displacement and hull centers of gravity or providing the model sinkage, trim and heel. We will select the float plane option and give the model 0 sinkage, heel and trim. Since the model is only the half hull, we will select *Mirror About Centerplane*. We will also select *Real-Time Hydrostatics* so we can see how our parameters change when we modify the hull shape.

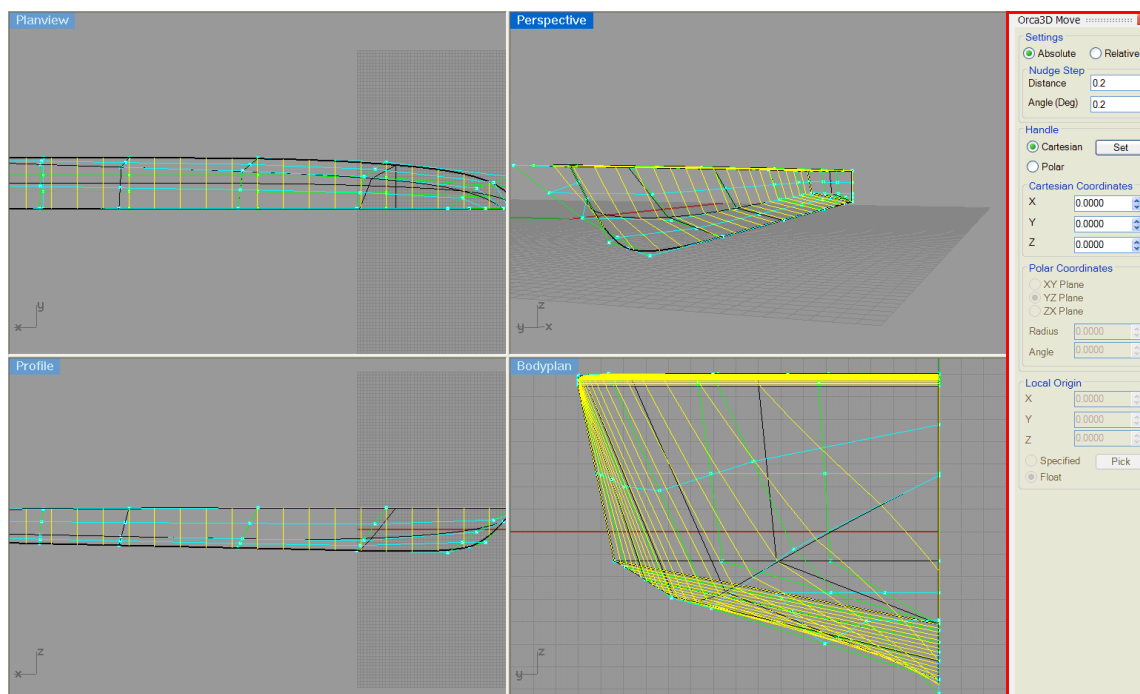
To run the design hydrostatics calculations, click and hold over the Compute Hydrostatics & Stability icon  and the fly out menu will appear and you can select the Compute Design Hydrostatics icon.



We will now select all the hull surfaces again and turn on the Orca3D Control Points by

clicking the Orca3D Control Points On icon . These points are similar to Rhino Control Points, but the Orca Sections will automatically update as Orca3D Control Points are moved.

Orca3D Move can be initialized from the Orca3D Move icon . This will open the Orca3D Move dialog box on the right hand side of the screen.

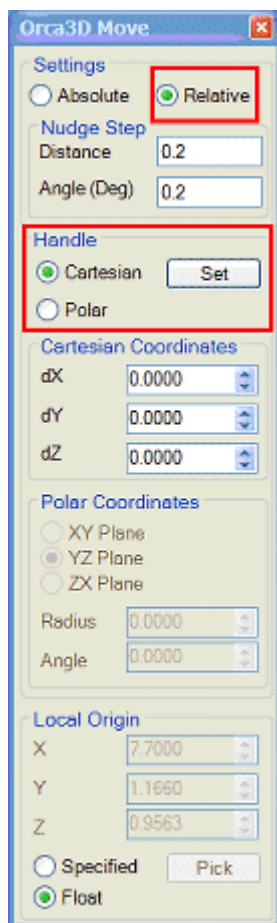


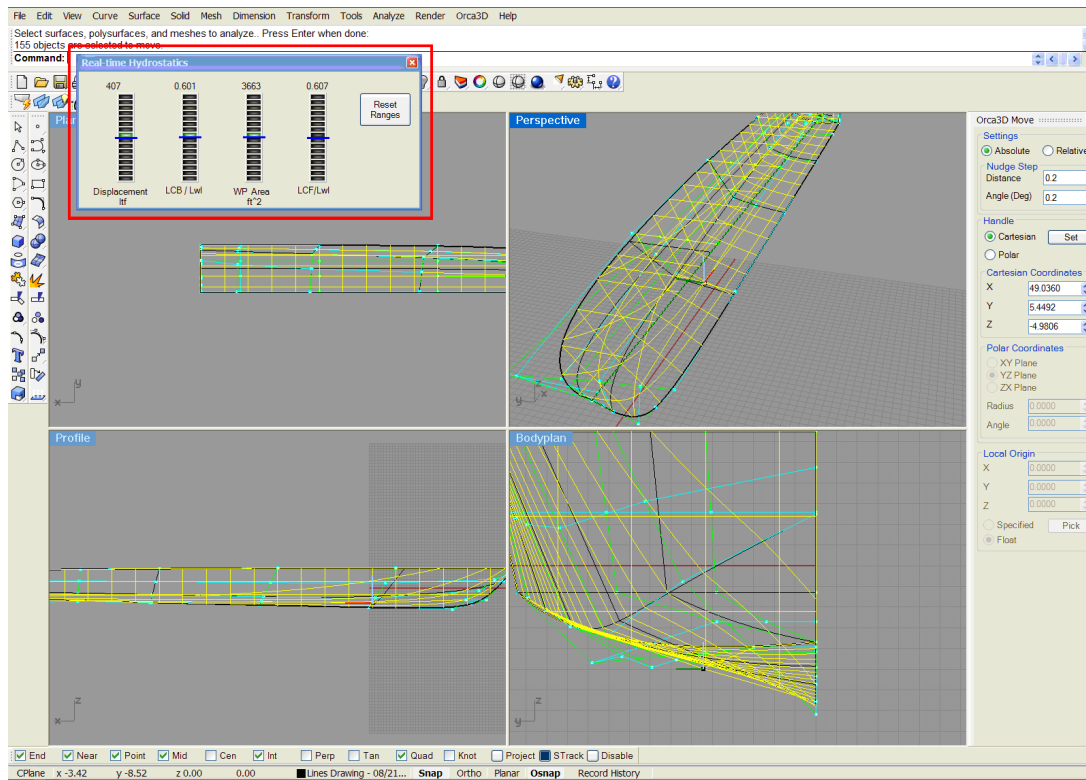
Now instead of creating stations and lofting surfaces through them, we are able to manipulate a parent hull and have the stations update automatically as the Orca3D control

points are moved. These points can be moved in relative or absolute, and Cartesian or polar coordinates.

Points can also be moved one at a time or in groups. Multiple points can be selected by holding the Shift key and clicking on the desired points, or selecting multiple points using the mouse select box. The single point you choose, or the last point in the group chosen, will automatically become the Handle. The handle is the point whose coordinates will fill in the X, Y, and Z coordinate boxes, and all points will be moved the change in this point's coordinates. The handle can also be set to a different location other than one of the chosen points from the Handle section of the Orca3D Move dialog box.

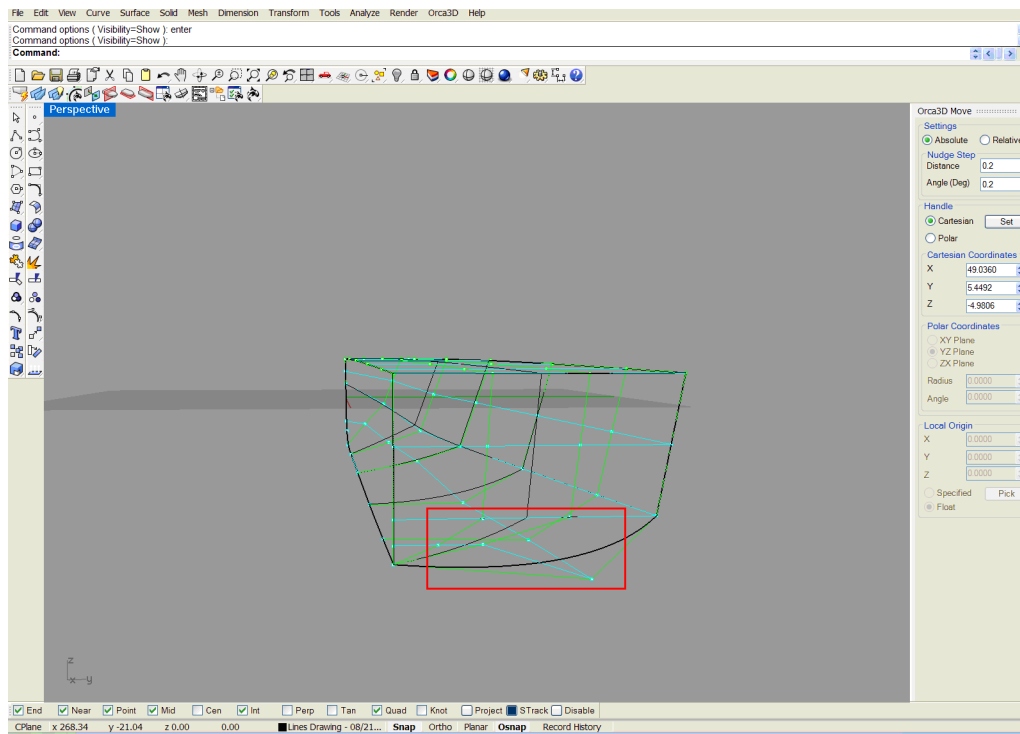
If Relative movement is selected, the Cartesian Coordinates values will be automatically set to 0 and the selected points will be moved the defined dX, dY, and dZ values from the handle.



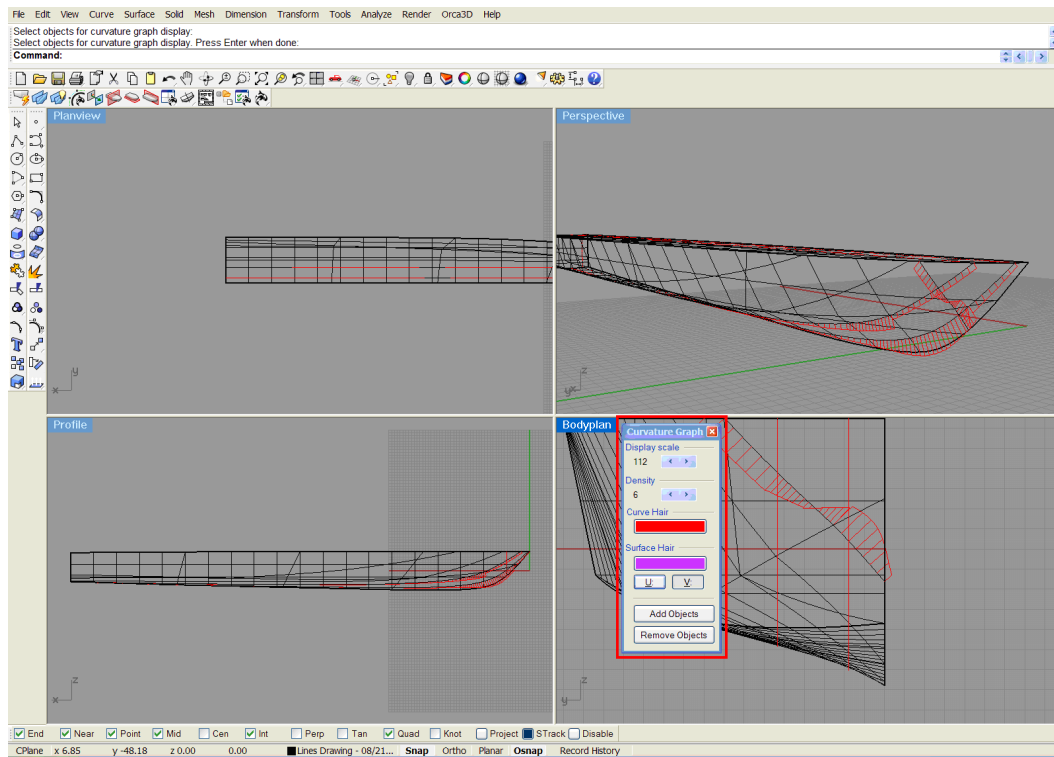


Imagine we plan to install an azimuthing thruster or water jets and want a relatively flat area in the aft portion of the hull bottom. We can use OrcaMove to manipulate control points in the desired region and “flatten” out the hull bottom.

In order to do this, we’ll select the Orca control points in the aft hull bottom section and move them in the negative Z direction and the positive Y direction. Notice how the stations update as the hull surface updates. This same process can be used for any part of the hull to broaden the bow or increase/decrease the deadrise, for example.

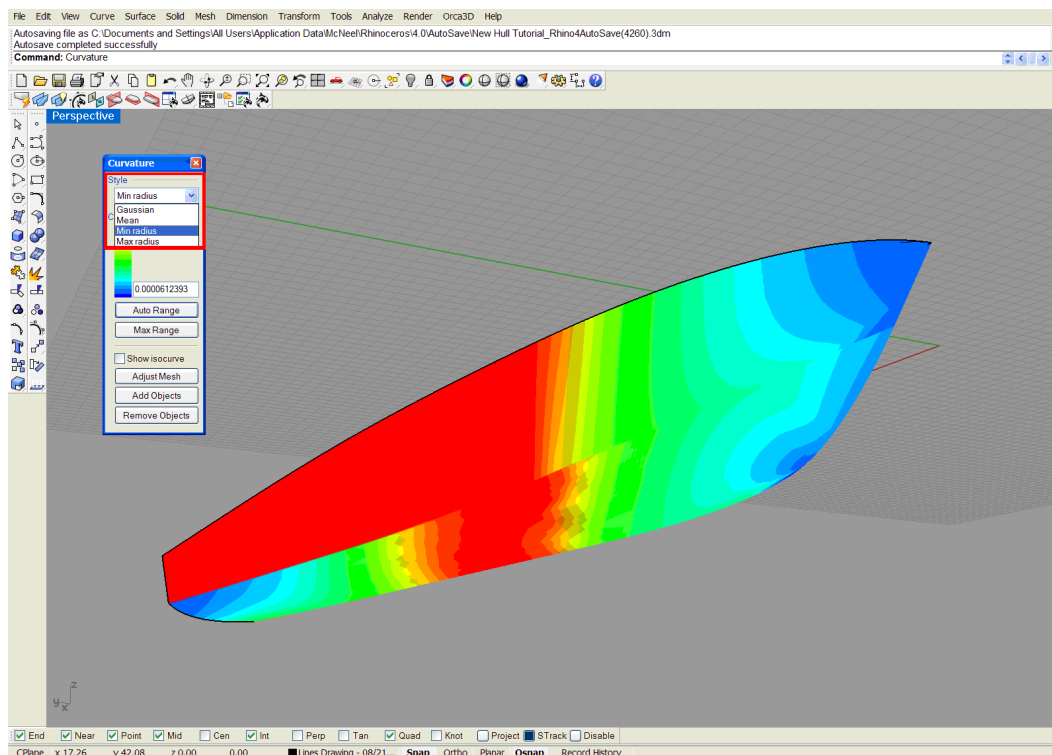


Once the hull is modeled as desired, the fairness of the hull can be evaluated using Rhino's curvature analysis functions. The first method is to plot a curvature graph for selected curves and surfaces. To do this, type the command: *CurvatureGraph* and press Enter. You can now select hull or section curves and curvature graphs will be plotted for each selected object. The dialog box that opens with this command allows you to adjust the length, frequency, color and u- and v-direction display of the curvature indicators plotted by the function.



The Curvature Graph dialog box also allows you to add and remove objects to have their curvature plot turned on or off. To do this, select an object(s) and click either *Add Objects* or *Remove Objects*.

The second method for analyzing the fairness of the hull is a Curvature Analysis of the surfaces. This function can be run by typing the command: *CurvatureAnalysis*. You will be prompted to select the surface to analyze. We will select the hull surface and press Enter. The dialog box will open and allow you to choose between Gaussian, Mean, Min Radius or Max Radius. The Gaussian curvature is a product of the two principal curvatures and the Mean curvature is the average of the two principal curvatures. A positive Gaussian curvature means the surface is bowl-like and a negative Gaussian curvature means the surface is saddle-like. The Max Radius option is useful for flat spot detection and the Min Radius option can determine if the surface has any points where the surface bends too tightly. For additional help with the Rhino curvature analysis functions, please see the Rhino Help File.



The hull can now be used to analyze additional hydrostatic conditions, create righting arm curves, create a lines drawing or create an offset table.

The righting arm and immersed area curves can be created by clicking the Hydrostatics &



Stability icon. To access this icon, you may need to click and hold on the Design Hydrostatics icon and this option will appear on the fly out toolbar. This will open a dialog box similar to the design hydrostatics window. The model can be defined again by either weight and centers of gravity or by a float plane. You may enter several values in each text box to create a number of model orientations. For this example, we'll use the float plane option, but now set the model sinkage to 0.75 feet. Again, we want to click the *Mirror About Centerplane* since we only have a half hull. We now have a few more options available. We can add a plane to represent the water surface or transform the model to the resultant condition based on our defined model orientation.

We will click the *Compute Righting Arm at these Heel Angles* box and input our desired heel angles in the corresponding text box. We are interested in angles 0 to 180 degrees in 10 degree increments so we can enter this as a comma separated list. When this box is selected, you must also enter a VCG. Click *Calculate* to create the hydrostatics and stability report.

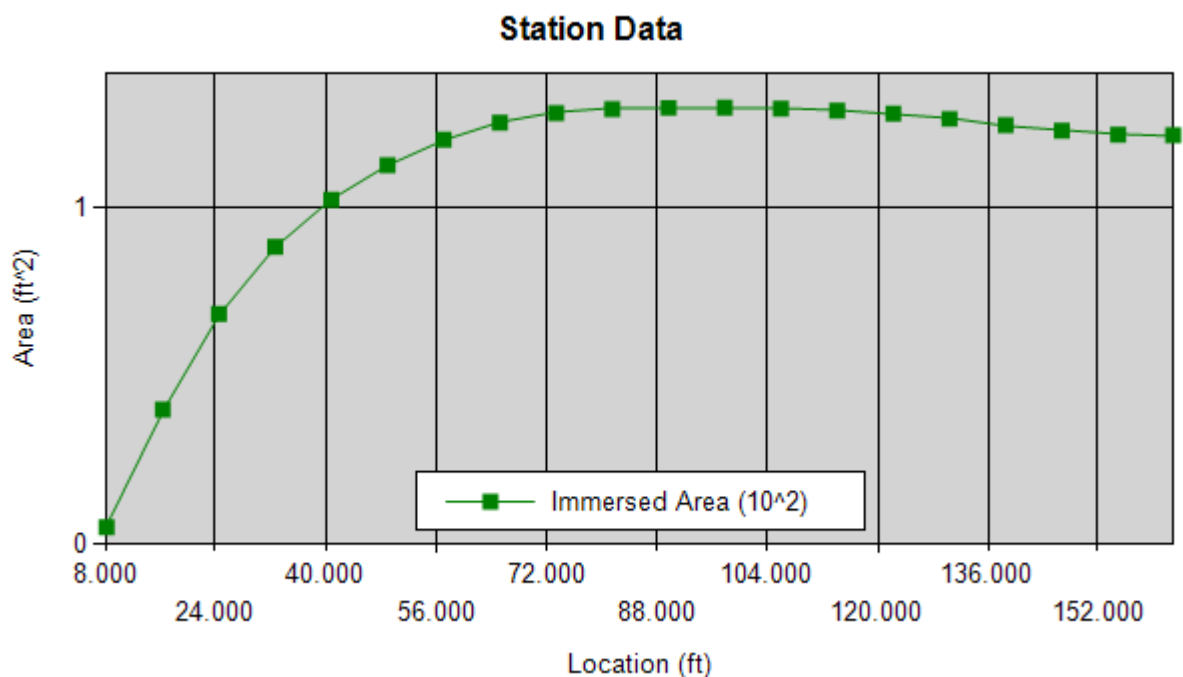
Orca3D Hydrostatics & Stability Analysis

Description:

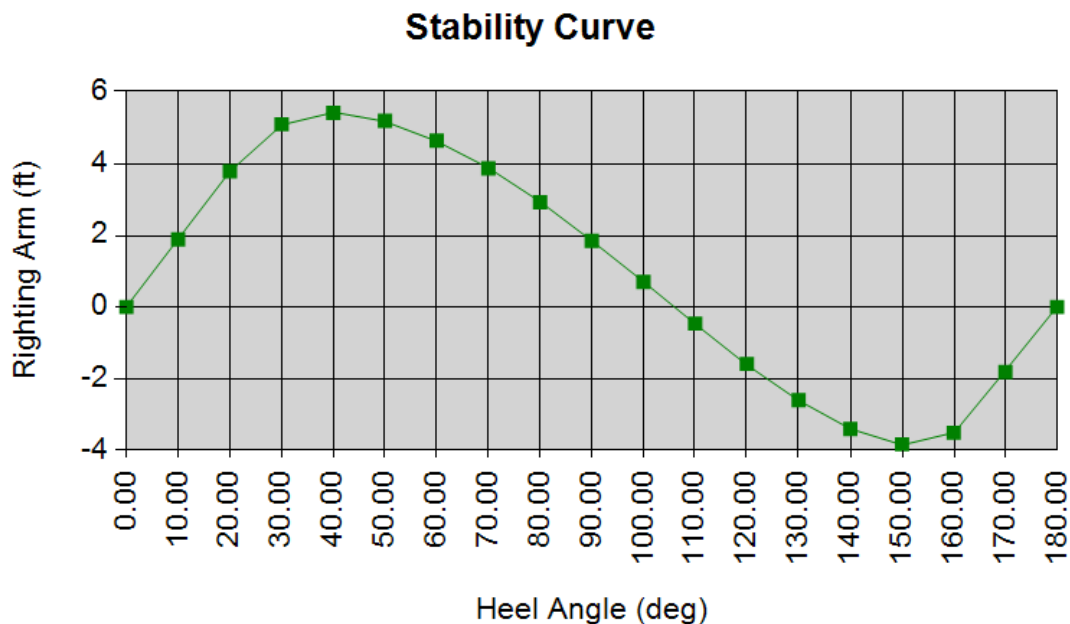
☐ Weight kgf or ☒ Model Sinkage ft
☐ LCG ft or ☒ Model Trim deg
☐ TCG ft or ☒ Model Heel deg
☒ VCG ft


☐ Override Initial Plane Height for Free Float Iteration: ft
☒ Mirror About Centerplane
☐ Add Plane(s) Representing Water Surface
☐ Transform Model to Resultant Condition
☒ Compute Righting Arm at these Heel Angles: e.g. 0,5,...,30,40,...,90
☐ Print Full Output for Heeled Conditions
☐ Also Write Output To CSV File:

The hydrostatics and stability report provides your model dimensions, volumetric values, hull form coefficients and static stability parameters. The report also provides an immersed area plot (if stations are defined):




And a righting arm curve:

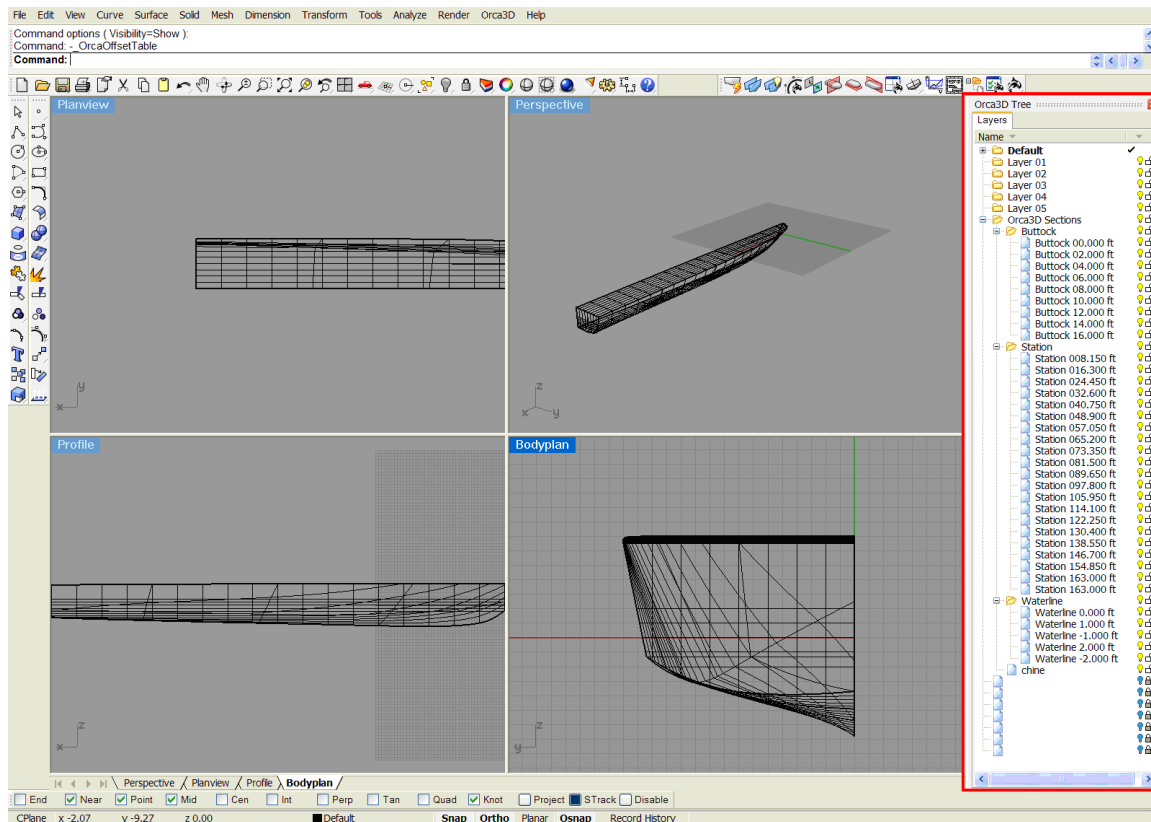


To create a table of offsets in Microsoft Excel, right-click on the Lines Drawing icon . This will bring up the option to *Include all Curves*, *Include Orca3D Curves Only*, or *Select Curves to include*.




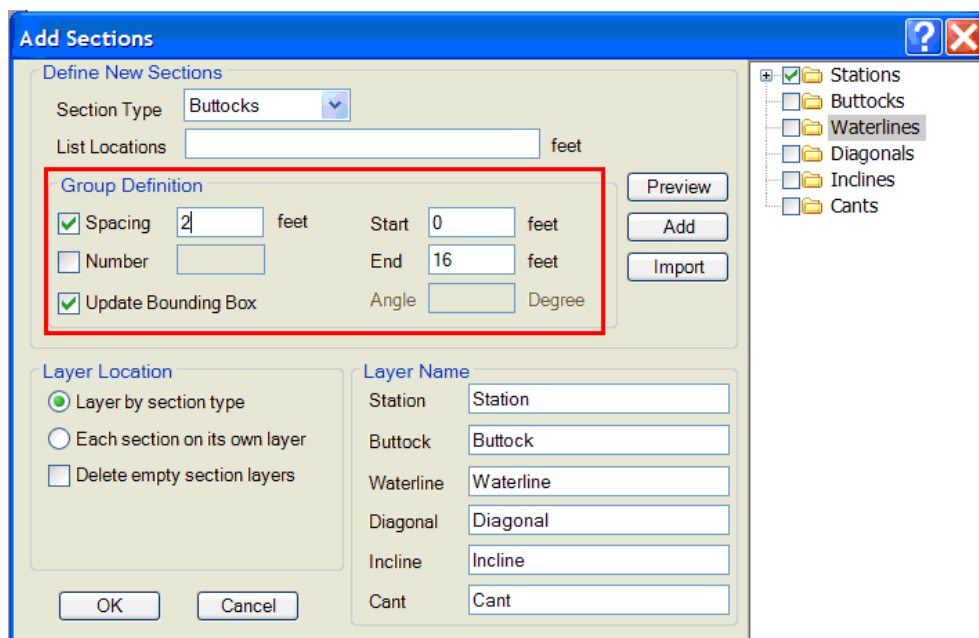
Including all curves will select all defined section curves, and any additional curves created in Rhino. For instance, you could create a curve along the chine and its offsets would then be included in the table. For this example we will create a chine curve. In order to do this, choose Curve from the Rhino File menu, then Curve from Objects -> Extract Isocurve. This will prompt you to choose the surface to extract the curve from. Select the hull surface and then select the isocurve that represents the chine and press Enter. You can now open the

Orca Tree by clicking on the Orca3D Tree icon . This will show you the different layers in your model as well as the Orca3D sections you have defined. We will rename our new curve "chine."

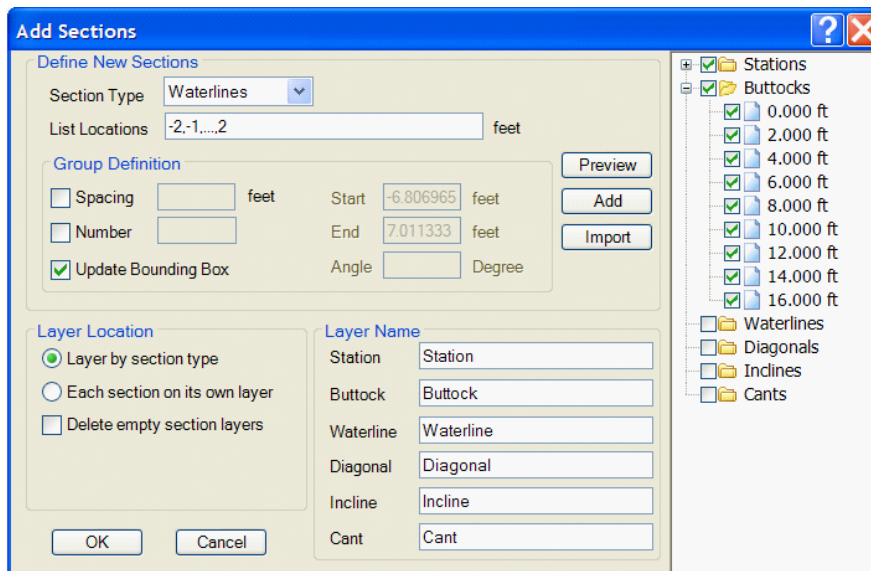


For a more detailed offset table, we will add buttocks and waterlines to our model using the same technique as we did to add sections. Highlight the hull surfaces and click the Orca3D

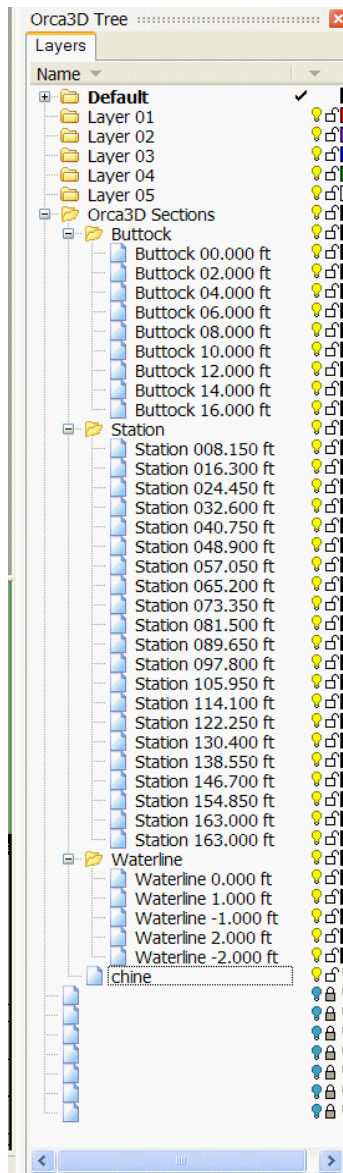
Sections icon . We will now add buttocks spaced at 2 feet apart using the automatically updated bounds and click Add.



We will also add waterlines at -2,-1,0,1, and 2 feet. This can be entered as a comma separated list: -2,-1,...,2 in the List Locations text box and Orca will automatically add waterlines at the desired locations. Click Add.



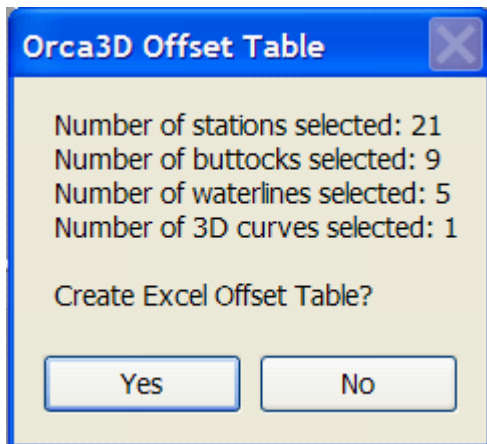
Back in the Orca Tree we now can see our stations, buttocks, waterlines and chine curve.



We are now ready to create our offset table. We will right-click on the Lines Drawing icon



and select *Include all Curves* from the fly out menu. This will automatically include all the station, buttock, waterline and chine curves in the offset table. Before the table opens, a dialog box will open giving a summary of the selected curves.



Select Yes and a Microsoft Excel file will open with two tabs: Buttock Heights and WL Half-Breadths. The WL Half-Breadths tab will provide the transverse offsets for each station at each waterline and the 3D curve we named “chine.”

TABLE OF OFFSETS							
File Name:		New Hull Tutorial.3dm					
Units:		Feet					
Absolute Tolerance:		0.01					
WATERLINE HALF-BREADTHS							
Station	Waterline -2.000	Waterline -1.000	Waterline 0.000	Waterline 1.000	Waterline 2.000	chine	Station
8.150		0.528	1.418	2.363	3.422	2.548	8.150
16.300	3.504	4.645	5.715	6.523	7.308	5.420	16.300
24.450	6.106	7.364	8.033	8.686	9.326	7.137	24.450
32.600	8.277	8.867	9.446	10.016	10.577	8.279	32.600
40.750	9.345	9.878	10.406	10.928	11.446	9.095	40.750
48.900	10.144	10.646	11.145	11.641	12.134	9.748	48.900
57.050	10.789	11.269	11.746	12.220	12.693	10.315	57.050
65.200	11.298	11.758	12.217	12.674	13.129	10.804	65.200
73.350	11.688	12.133	12.576	13.017	13.457	11.220	73.350
81.500	11.988	12.418	12.847	13.274	13.700	11.575	81.500
89.650	12.233	12.650	13.064	13.477	13.889	11.888	89.650
97.800	12.449	12.850	13.249	13.647	14.043	12.177	97.800
105.950	12.647	13.031	13.413	13.794	14.173	12.449	105.950
114.100	12.838	13.203	13.566	13.928	14.288	12.711	114.100
122.250	13.031	13.376	13.719	14.060	14.400	12.971	122.250
130.400	13.235	13.559	13.880	14.199	14.517	13.238	130.400
138.550	13.203	13.758	14.054	14.349	14.642	13.513	138.550
146.700	13.216	13.973	14.242	14.510	14.777	13.798	146.700
154.850	13.307	14.207	14.446	14.684	14.921	14.093	154.850
163.000	13.514	14.462	14.667	14.872	15.077	14.400	163.000
163.000	13.514	14.462	14.667	14.872	15.077	14.400	163.000
	0.000	0.000	0.000	0.000	0.000		

The Buttock Heights tab will provide the vertical intersections of the buttock curves with the station curves at the deck and hull bottom locations. The vertical intersection of the chine curve at each station is also included.

FILE Edit View Insert Format Tools Data Window ACT! Help


TABLE OF OFFSETS

File Name: New-Hall Tutorial 3dm
Units: Feet
Absolute Tolerance: 0.01

BUTTOCK HEIGHTS

Station	Buttock 0.000	Buttock 2.000	Buttock 4.000	Buttock 6.000	Buttock 8.000	Buttock 10.000	Buttock 12.000	Buttock 14.000	Buttock 16.000	chase	Station
8.550	-1.014	0.623	2.535	4.452	6.361						8.550
10	7.006	7.006	7.006	7.006	7.006						
12	-5.700	-3.445	-1.556	0.350	2.307	5.677					16.300
13	7.009	7.009	7.009	7.009	7.009	7.009					
14	-6.596	-4.347	-2.446	-0.700	-0.048	3.078	6.416				24.450
15	7.011	7.011	7.011	7.011	7.011	7.011	7.011				
16	-6.803	-5.532	-4.343	-3.219	-2.145	0.972	4.598				32.600
17	7.011	7.011	7.011	7.011	7.011	7.011	7.011				
18	-6.750	-5.756	-4.800	-3.871	-2.959	-0.769	0.981				40.750
19	7.009	7.009	7.009	7.009	7.009	7.009	7.009				
20	-6.590	-5.809	-5.034	-4.259	-3.477	-2.286	1.728	5.839			48.900
21	7.003	7.003	7.003	7.003	7.003	7.003	7.003	7.003			
22	-6.412	-5.783	-5.142	-4.484	-3.804	-3.057	0.535	4.791			57.050
23	6.993	6.993	6.993	6.993	6.993	6.993	6.993	6.993			
24	-6.234	-5.710	-5.162	-4.588	-3.962	-3.338	-0.472	3.325			65.200
25	6.979	6.979	6.979	6.979	6.979	6.979	6.979	6.979			
26	-6.056	-5.607	-5.128	-4.632	-4.095	-3.448	-1.299	3.241			73.350
27	6.961	6.961	6.961	6.961	6.961	6.961	6.961	6.961			
28	-5.978	-5.451	-5.064	-4.591	-4.065	-3.476	-1.974	2.708			81.500
29	6.938	6.938	6.938	6.938	6.938	6.938	6.938	6.938			
30	-5.700	-5.372	-4.993	-4.557	-4.053	-3.468	-2.560	2.271			89.650
31	6.911	6.911	6.911	6.911	6.911	6.911	6.911	6.911			
32	-5.522	-5.255	-4.936	-4.526	-4.042	-3.467	-2.745	1.892			97.800
33	6.880	6.880	6.880	6.880	6.880	6.880	6.880	6.880			
34	-5.339	-5.134	-4.856	-4.452	-4.028	-3.442	-2.706	1.545			105.950
35	6.845	6.845	6.845	6.845	6.845	6.845	6.845	6.845			
36	-5.150	-4.803	-4.474	-4.047	-3.625	-3.088	1.189				114.100
37	6.807	6.807	6.807	6.807	6.807	6.807	6.807	6.807			
38	-4.951	-4.655	-4.672	-4.383	-3.970	-3.402	-2.636	0.024	6.764		122.250
39	6.764	6.764	6.764	6.764	6.764	6.764	6.764	6.764			
40	-4.729	-4.693	-4.538	-4.286	-3.968	-3.346	-2.609	0.376	6.719		130.400
41	6.719	6.719	6.719	6.719	6.719	6.719	6.719	6.719			
42	-4.510	-4.492	-4.386	-4.175	-3.835	-3.327	-2.592	-0.192	6.670		138.550
43	6.670	6.670	6.670	6.670	6.670	6.670	6.670	6.670			
44	-4.353	-4.286	-4.226	-4.063	-3.779	-3.306	-2.600	-0.980	6.607		146.700
45	6.617	6.617	6.617	6.617	6.617	6.617	6.617	6.617			
46	-3.994	-4.073	-4.070	-3.967	-3.734	-3.325	-2.656	-1.544	6.561		154.850
47	6.561	6.561	6.561	6.561	6.561	6.561	6.561	6.561			
48	-3.700	-3.851	-3.924	-3.898	-3.742	-3.405	-2.788	-1.647	6.500		163.000
49	6.500	6.500	6.500	6.500	6.500	6.500	6.500	6.500			
50	-3.851	-3.924	-3.898	-3.742	-3.405	-2.788	-1.647	6.500			163.000
51	6.500	6.500	6.500	6.500	6.500	6.500	6.500	6.500			

Buttock Heights / WL Half-Breadths /

To create the lines drawing, click the Create Lines Drawing icon . All the defined sections will be automatically found and included in the lines drawing.

Orca3D Lines Drawing

Display Options | Print Options | Title Block Options

Curves to Draw

- ☒ Orca3D Sections
- ☐ All Curves
- ☐ Select Curves

☒ Draw Border

☒ Draw Title Block

☒ Display Principal Characteristics

☒ Draw Coordinate Axes

☒ Create Section Labels

☐ Use Curve Display Colors

Station Numbering

Station 0 Location (Relative to Origin) feet

Station Spacing feet

Bodyplan Split Location feet

Section Label Options

Label Precision decimals

Label Text Size inches

Section Display Colors

Stations ☐

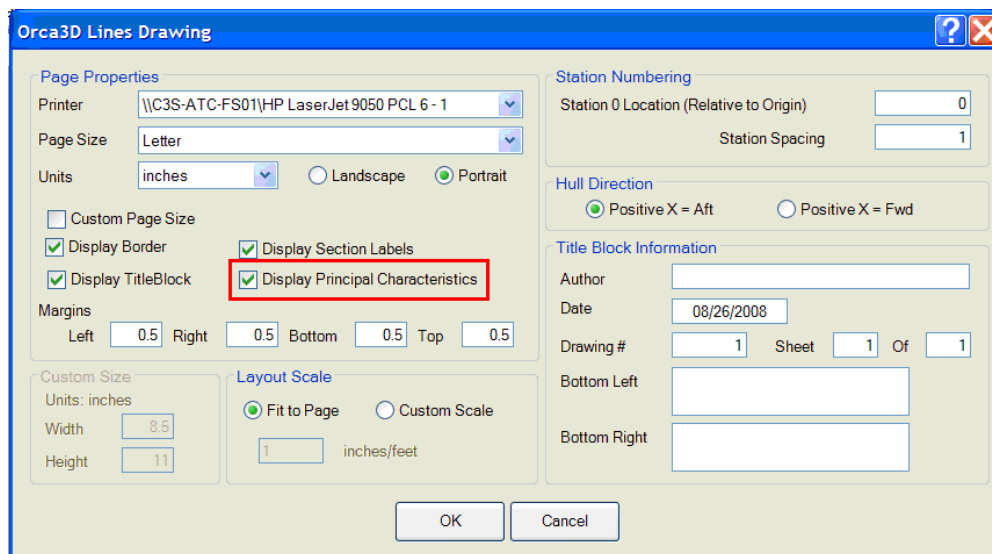
Buttocks ☐

Waterlines ☐

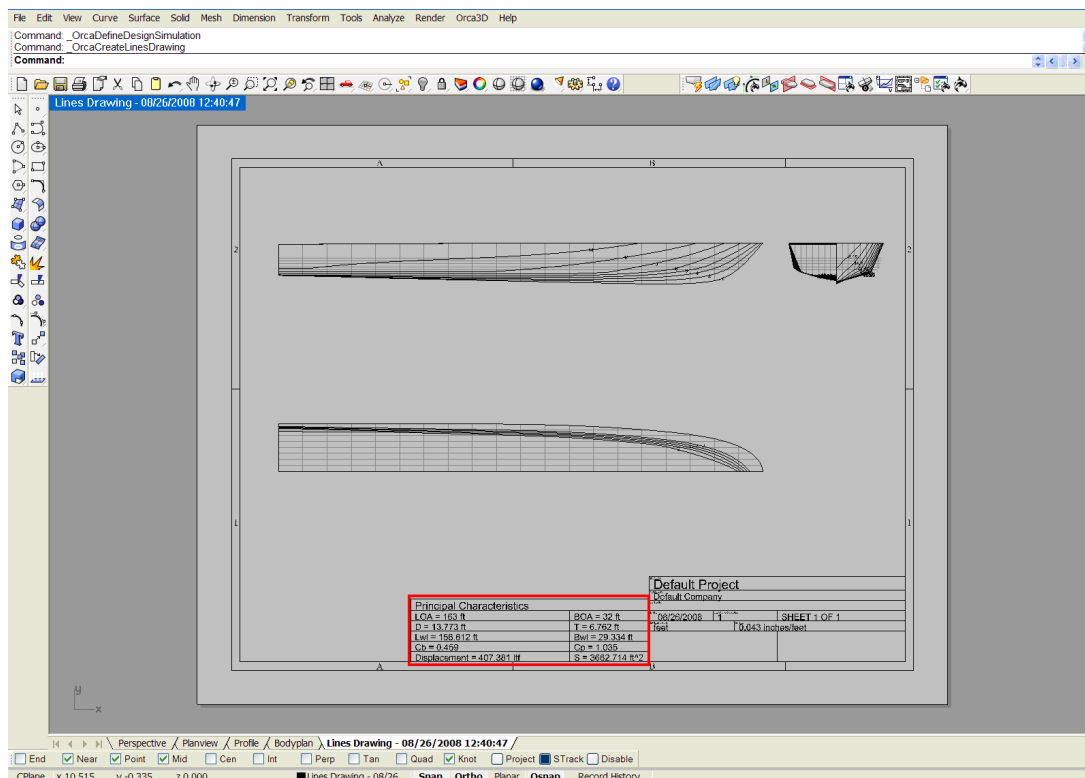
Diagonals ☐

Inclines ☐

OK Cancel



The Orca3D Lines Drawing dialog box will open allowing you to customize your lines drawing. A message will appear if you do not have a design condition defined. If the condition is defined, you have the option of displaying the principal characteristics in the lines drawing if desired.



The Lines Drawing is created on a new tab within the Rhino window. The Principal Characteristics will be included in the lines drawing if the design condition is defined and the option is selected in the Lines Drawing dialog box. The section labels and title block can be

modified if desired.

Note: the lines drawing does not update as the hull is modified, and therefore if changes are made, a new Lines Drawing must be created to incorporate these changes.

For additional assistance, please see the Orca3D Online videos or visit the online forum at www.orca3d.com/forum.


Part

VII

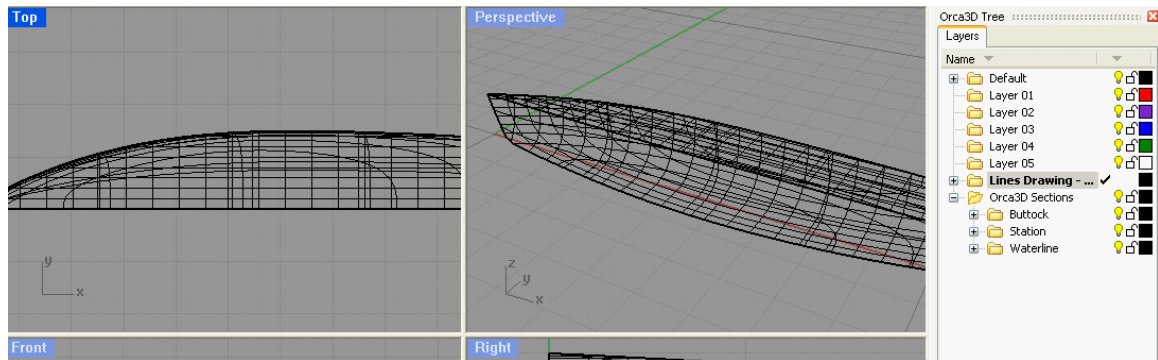
7 The Orca3D Tree

The Orca3D Tree is a utility that improves upon the default layers utility in Rhino. In addition to the typical layer capabilities of visibility, locking and changing the color, it allows you to:

- See which objects reside in each layer
- Renaming objects
- Move objects from layer to layer
- Hide all objects or layers except the object(s) or layer(s) selected

Toolbar	
Menu	Orca3D > Orca3D Tree
Command	OrcaShowTree (Press Enter Twice)

1. Start the command with the toolbar icon, menu selection or keyboard command.
2. The Orca3D Tree Dialog Box will appear docked on the right side of the screen:

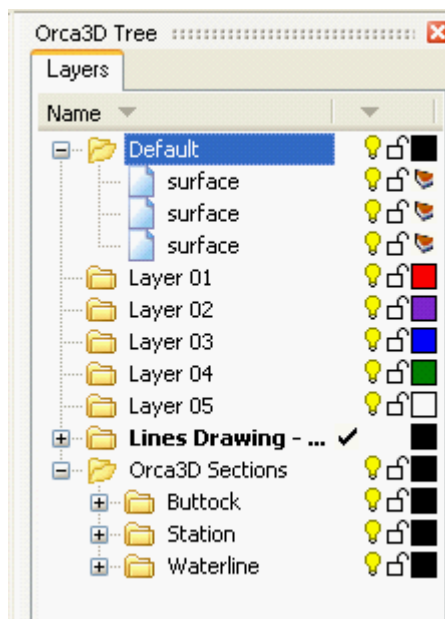


3. Decide which function of the Orca3D Tree you wish to perform and find the instructions below.

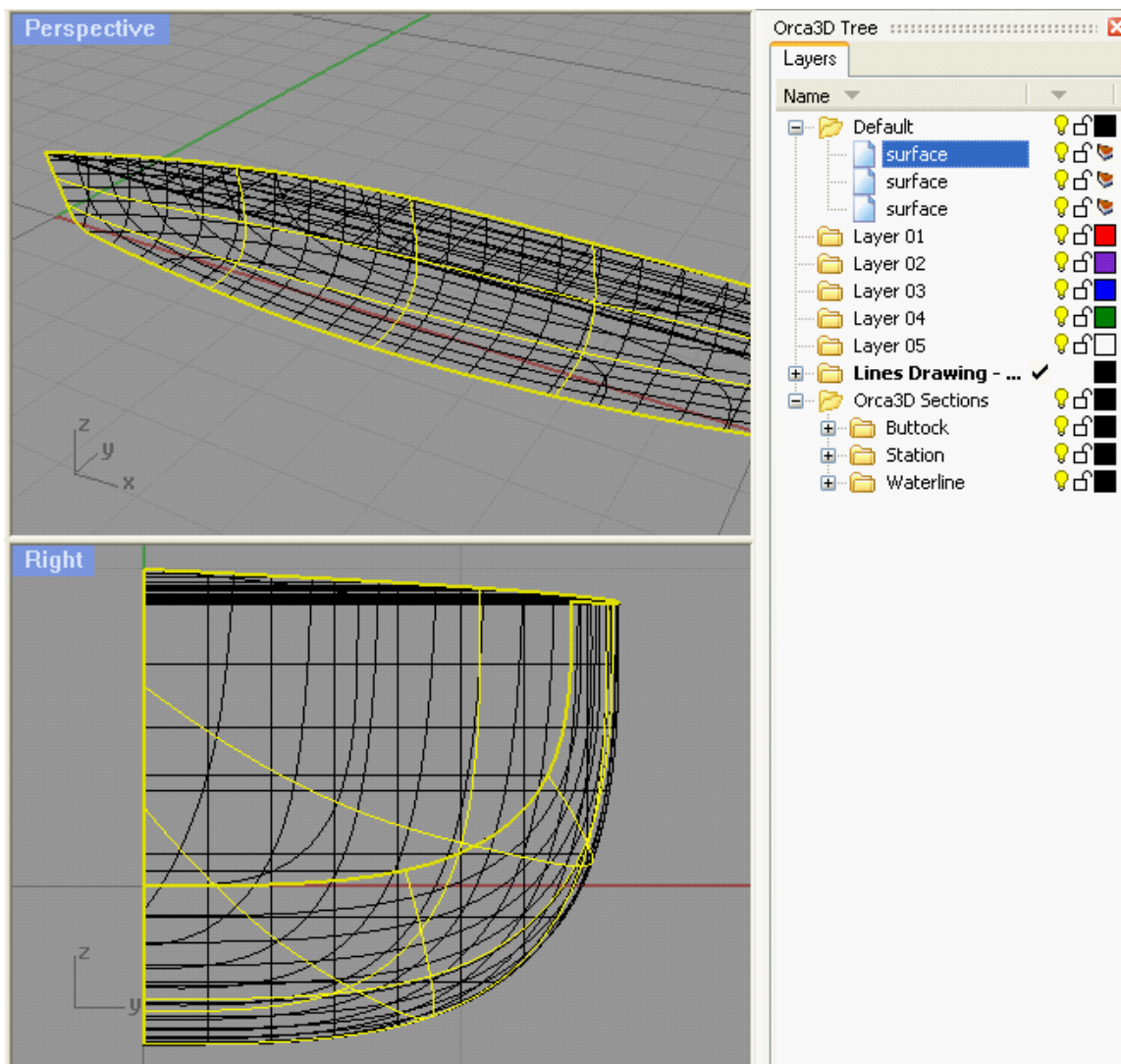
Show all Objects in a Layer

Decide which layer you wish to see more details of and click the plus icon to the left of the layer name.

The Orca3D Tree Dialog Box will change to look like this:



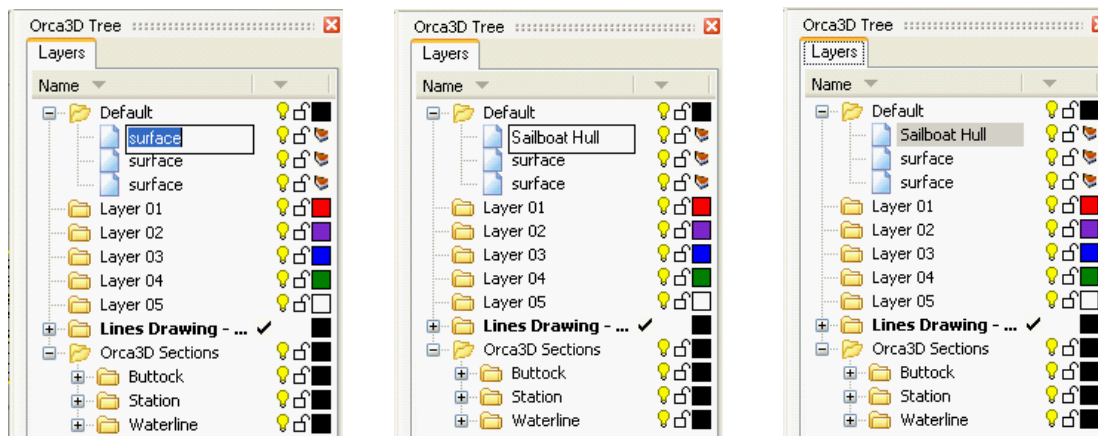
For this use the Default layer was expanded. We can now see that there are three objects located in the Default layer, all surfaces.



If you select one of the objects in the Orca3D Tree, the same object will be selected in the viewports you have opened. Conversely, selecting objects in the viewports will also select them in the tree.

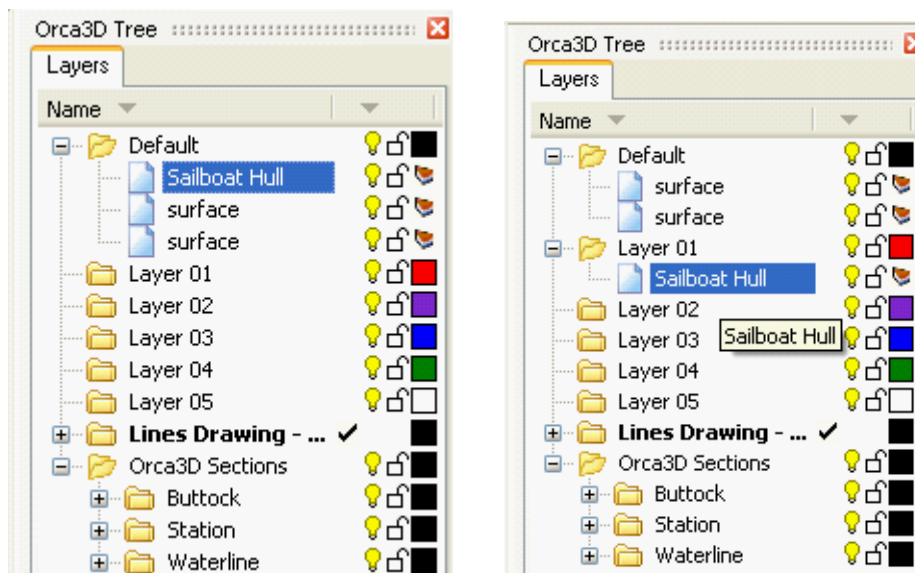
Renaming Objects using the Orca3D Tree

Decide which object you wish to rename. Then slow double left-click on the name in the Orca3D Tree. Next type whatever you wish to rename the object to. Finally Press Enter to finish renaming the object.



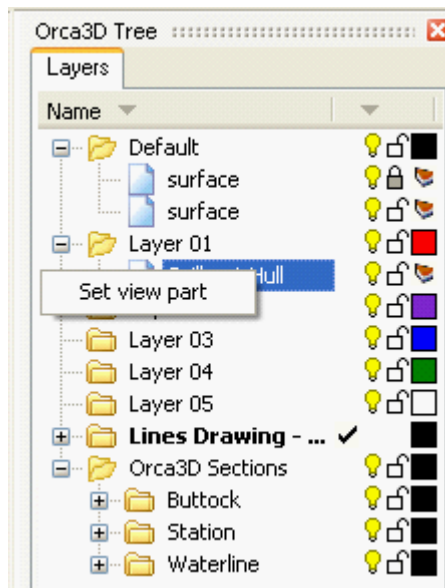
Moving Objects from Layer to Layer

First, decide which object you would like to move. Next, select that object and left-click and hold. Then move the mouse to hover over the layer which you wish to move the object to, and release the left mouse button.



Hiding Objects

Decide which objects you wish to stay visible. Then select them all and right-click. The following menu will appear:

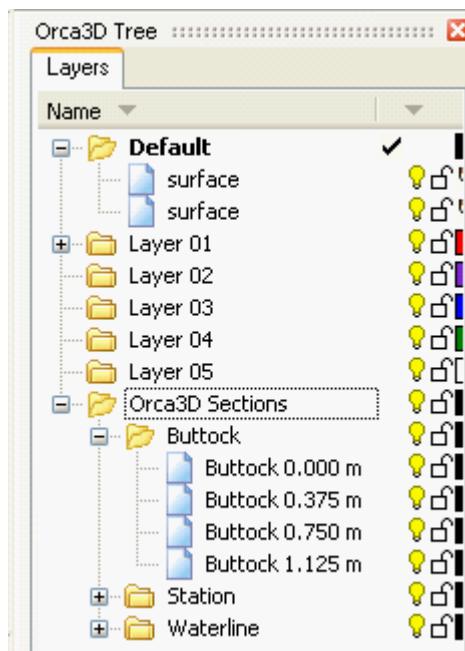


- Left-click the option “set view part” and everything but the objects you have selected will become invisible.
- To return everything to normal, simply click the lightbulb icons next to the objects you wish to make visible again.
- To hide the docked Orca3D Tree dialog box simply either click the toolbar icon, type the command, or navigate to it on the menu.

Understanding the Orca3D Tree

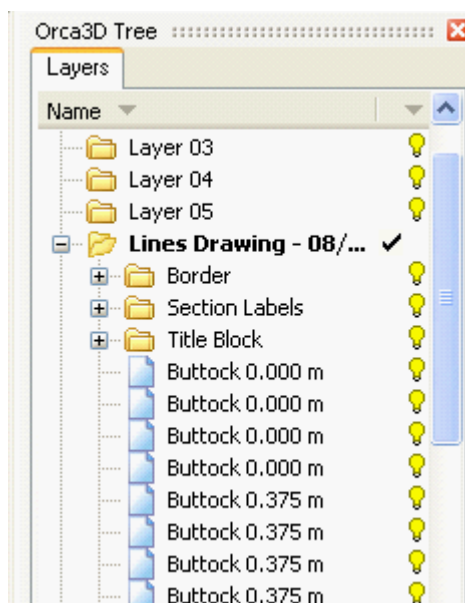
The objects that Orca3D creates and are visible in the Orca3D Tree include the hull surfaces, section curves, and lines drawing curves and objects. As you can see from above, the hull surfaces are placed into whatever the current layer is at their time of creation. On the other hand, the Orca3D sections and Lines Drawing curves and objects are placed into their own layers that are created by Orca3D.

The Add Section Dialog creates a new Orca3D Sections layer when it creates the sections. Within this layer are layers for each type of section such as buttock, station, etc. Then within each of these layers the individual section curve objects are placed. An example of how section curve objects are placed into layers is shown below:



Note: It is not possible to edit the section curves' properties like display color and name here. These properties are controlled by Orca3D and can be edited in the Add Sections dialog.

The Orca3D Lines Drawing command uses a similar method that the Add Sections command uses. The Lines drawing creates a new layer called Lines Drawing [date] [time], where date and time are the current date and time at the creation of the lines drawing. Within this layer are three or four sub layers that all contain objects that correspond to their layer names. The actual section curves used in the lines drawing are stored in the top most parent layer. An example of the Lines Drawing layer in the Orca3D Tree is shown below:



Part



8 Hull Design

This section describes the most common basic tasks you will use when designing hulls with Orca3D. It is designed as a "How-To" guide. You can use the table of contents as an index. Although it is organized roughly in the order that you would perform the tasks you don't need to begin at the beginning and work your way through. Every topic contains comprehensive links to background information and other relevant subjects so you can just pick out the task you need to perform and begin.

See also:

[Introduction](#) ⁷⁰

[Quick Start Tutorial](#) ⁹³

[FAQ-Hull Design & Fairing](#) ⁴⁸⁹

8.1 Introduction

By itself, Rhino is a very powerful surface modeling system, and can be used to design and fair hullforms. However, with the addition of a few new tools, it can be even more productive. Orca3D enhances and leverages Rhino's capabilities.

There are two basic approaches to modeling hulls in Rhino:

1. Draw a series of curves (stations), and loft a surface through them. This approach has the advantage of creating a shape very quickly, and being assured that the surface passes through the desired station shapes. However, usually the surface that is created is greatly overdefined, and subject to unfairnesses which can be very difficult to remove. This approach is more useful for other surfaces found in marine vessels, such as portions of the superstructure.
2. Create a surface with a relatively low number of control points, and move those control points to "stretch" and "sculpt" the surface into the desired shape. Sections can be computed on the surface, to give the designer a better idea of the actual shape. This approach has the advantage of producing fair surfaces, but it can be more difficult to guarantee that the surface passes through a given point or points in space. In general, fairness is more important than passing exactly through a given point, so this approach is more effective (an exception to this might be trying to match the offsets of an existing hull for stability calculations, where fairness is not as important as matching the offsets exactly).

Orca3D is primarily focused on the second approach, known as "direct surface manipulation." Tools are provided to:

- Quickly generate a starting point ([Hull Assistants](#) ¹⁷⁵)
- Define stations, buttocks, waterlines, and other curves on the surface ([Sections](#) ¹²⁶)
- Display the sections in real time as the surface is modified ([Orca Control Points](#) ¹²¹)

- Display the hydrostatics in real time as the surface is modified ([Design Hydrostatics](#)^[132])
- Easily move control points to exact locations ([OrcaMove](#)^[122])
- Handle the transition of the surface as it wraps from the stem around the forefoot to the bottom, with slope and curvature continuity ([Corner Wrap](#)^[213])
- Create 3-View [Lines Drawings](#)^[216]
- Create [Tables of Offsets](#)^[224]
- [Export](#)^[227] section curves

Note that the Orca3D tools can be used on any type of surface, no matter how it was generated.

8.2 Hull Assistants

The Hull Assistants are intended to speed the process of creating a 3D surface that you can modify to create your final hull shape. It's very unlikely that they will automatically create your final hull form, but they can get you close very quickly. Once the 3D surface is created, you can modify it using the Orca3D control points, watching the sections and hydrostatics updating in real-time as you go.

For complete information on the Hull Assistants, please see the [Hull Assistants](#)^[98] topic in the Quick Start Tutorial section.

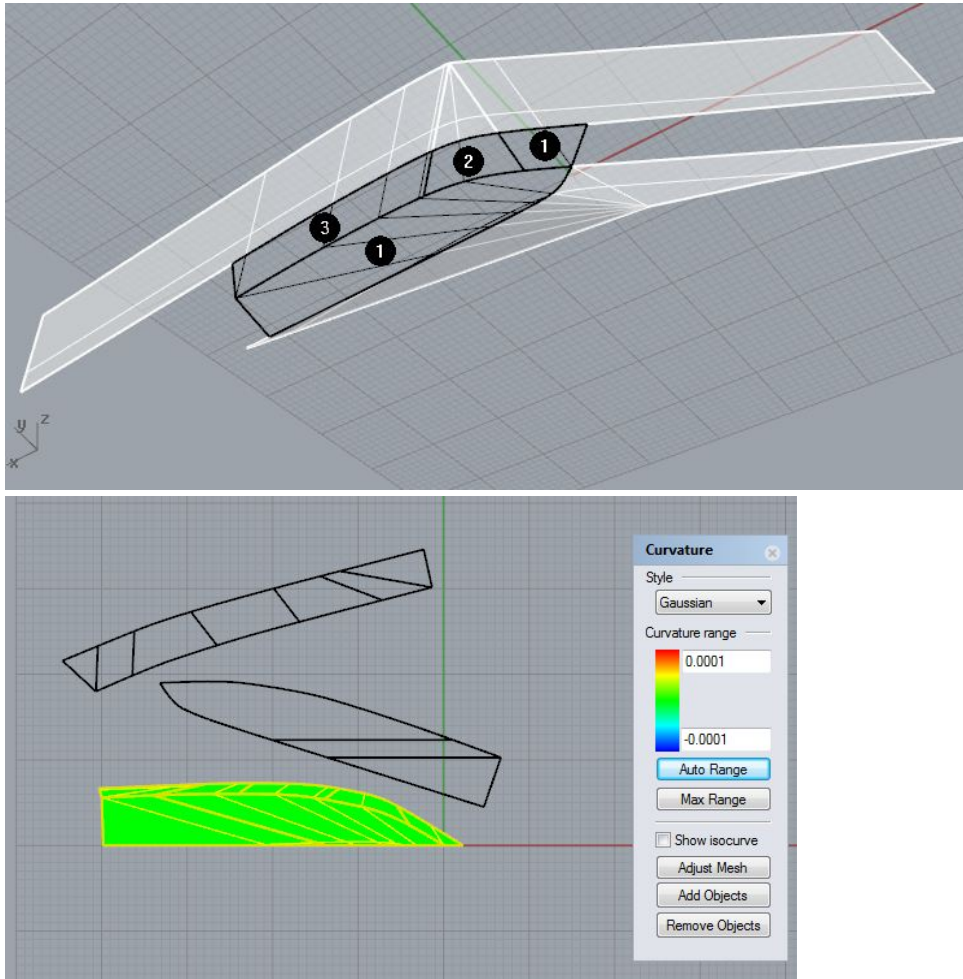
8.3 Developable Hulls

Introduction

Developable hulls are designed using surfaces with single curvature, so that they can be easily manufactured using sheet materials (e.g., plywood, aluminum, steel), without any working of the material. Examples of a single curvature surfaces are a cylinder and a cone; they can easily be unrolled into a flat sheet. On the other hand, a surface with compound curvature, such as a sphere or a saddle, cannot be exactly flattened without stretching or compressing the material. Another way to think of a developable, or single curvature, surface is that you can place a straight edge on any point in the surface, and there will be some orientation where it will sit flat on the surface.

There have been many different software approaches created to design developable surfaces. Most of them allow the user to create two curves (e.g., a sheer line and a chine line), and the program tries to find rulings between the curves, where the normals to each curve are parallel at the intersection of the ruling and the curves. Sometimes the rulings will cross each other or have dramatic changes in slope from one to the next, requiring the user to adjust the curve shape, and try again, without any real feedback on how to improve the situation. In general, the surfaces created with this approach are "mostly" developable, meaning that they can be manufactured with minor stretching or compressing of the plate, but it's difficult to know when "mostly developable" is good enough.

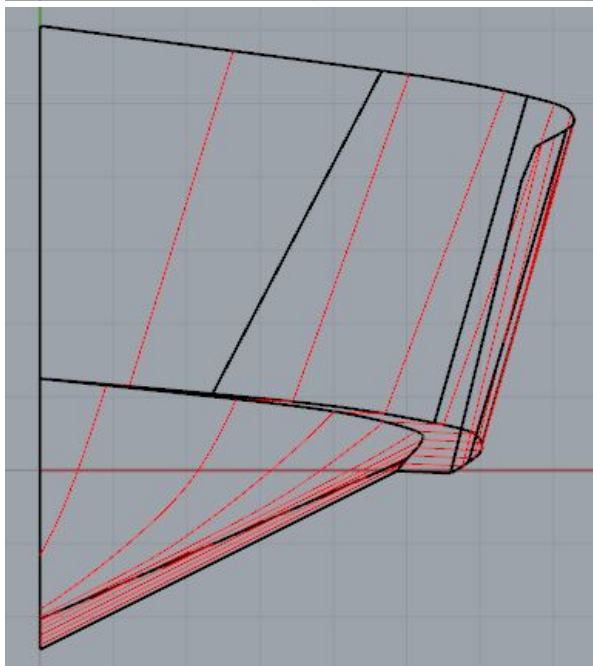
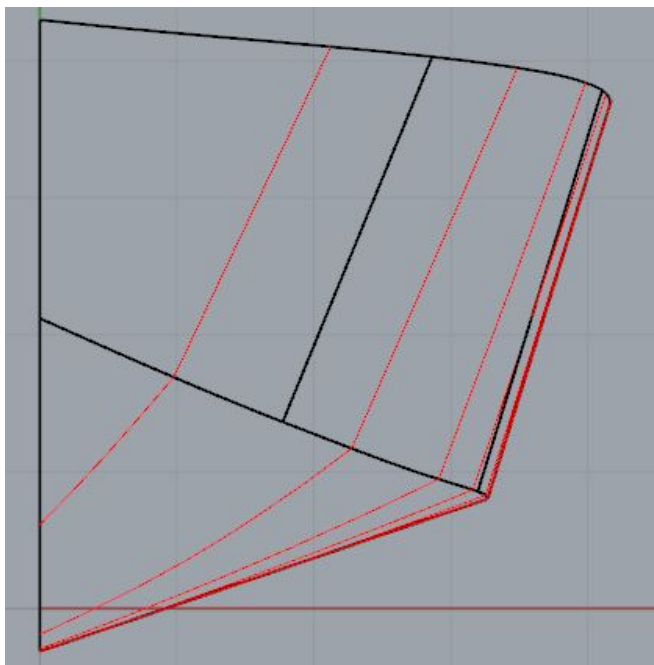
Orca3D's Developable Hull Assistant takes an entirely different approach, where the hull is created out of segments of cones and cylinders. With this approach, it is certain that the hull surface is exactly mathematically developable. In the example below, the bottom surface, below the chine, is made up of a single section of a cone. The topsides above the chine are made up of a cylinder (1), a cone (2), and another cylinder (3) (note that the underlying surfaces extend beyond the boundaries of the hull itself, and are trimmed to form the hull surface; the surface beyond the boundary of the hull, called the extrusions, is shown shaded). The next image shows the Gaussian Curvature analysis, and the unrolled bottom and topsides surfaces.

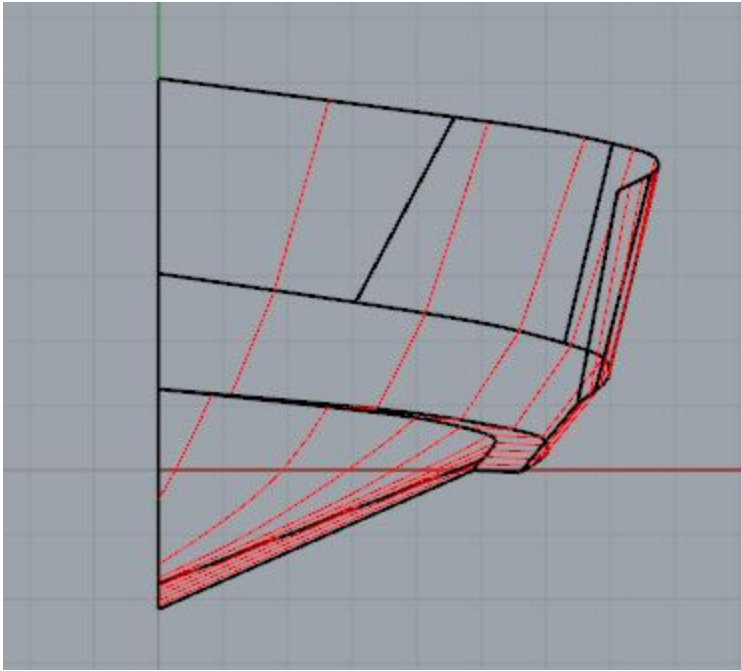


In the Assistant, the user is given control over the number and type of panels, the location of the vertex for the topsides and bottom (and for a mid-panel, not shown in the above example), the distance beyond the hull fore and aft to extrude the surfaces (extension length), and some controlling curves (e.g., the chine curve and the shape of the sheer line in profile view).

Unlike the other Orca3D Hull Assistants, the hull that is created is considered to be "final," because any further editing will likely distort the surfaces such that they are no longer developable. Of course they can be scaled and trimmed, but any change to the underlying control points will most likely result in a surface that is no longer developable.

The Developable Hull Assistant can create a hull with a single chine, a chine flat, and/or a knuckle in the topsides.





8.3.1 Definitions

The terms used in the Developable Hull Assistant are defined below. Each of the three tabs of the dialog will be addressed.

DevHullWizardForm

Description: Default Developable Hull Assistant

Dimensions Panels Geometry

Transom

Location 40 m

Rake 4 deg

Shear

Height 6 m

Trim 1.5 deg

Heel -5 deg

☐ Advanced Controls

Select Curve... Edit Curve...

Knuckle

Height 3 m

Trim 2 deg

Heel -5 deg

☒ Show Apexes and Master Curves

☐ Show Extrusions

☒ Bottom ☒ Top ☒ Show Ghosted

☒ Preview Hull

☐ Preview Sections

☐ Define Custom Sections ...

☐ Preview Hydrostatics

Create Hull Cancel Save Settings Back To Hull Library

Dimensions:

Transom: The surfaces are cut off at a plane defined by the Location and Rake angle. If your surfaces seem to be cut off ahead of the transom, that indicates that your Extension Length (on the Geometry tab) needs to be increased.

Sheer: The sheerline of the boat can be defined in two ways. The first is by defining a plane, using Height (on the world vertical axis), Trim, and Heel. This plane is then intersected with the surface to create the sheerline. The second approach, with Advanced Controls, is to select a curve that you have drawn using Rhino. This curve is projected horizontally to intersect and trim the developable surface. This means that in Profile view the surface will match your curve exactly, but it may not match in Plan View. By clicking on the Edit Curve button you can edit the control points on your curve. As always, a lower number of points will yield a smoother curve.

Knuckle: If you have chosen to include a Middle Strake (on the Panels tab), there will be a knuckle in the topsides. This knuckle is defined using a plane that is specified with a Height, Trim, and Heel. The surface between the chine and the knuckle is a cylindrical development, using the chine and the Middle Apex (on the Geometry tab), which is trimmed at the Knuckle plane.

Show Apexes and Master Curves: This turns on the display of the points for the Apexes and Master Curves, which are color coded.

Show Extrusions: The surfaces that are created are larger than the hull, and are trimmed at the transom, sheer, and centerline. Showing Extrusions will display the surfaces beyond these boundaries.

Preview Sections: This option will display 10 stations on the hull, and update them as the hull is modified. Define Custom Sections allows you to define any number of stations, buttocks, and waterlines.

DevHullWizardForm

Description: Default Developable Hull Assistant

Dimensions **Panels** Geometry

Top Strake

Panel #	Start Point (%)	Shape	Apex Ht
Panel 1	0	Cylinder	1
Panel 2	0.1	Cone	1
Panel 3	0.35	Cylinder	1
Panel 4	0.6	Cone	0.75
Panel 5	0.85	Cone	0.55

Bottom Strake

Panel #	Start Point (%)	Shape	Apex Ht
Panel 1	0	Cone	1
Panel 2	0.85	Cylinder	1

☐ Show Panel Labels
☒ Create Middle Strake
☒ Create Chine Flat

☒ Show Apexes and Master Curves
☐ Show Extrusions
☒ Bottom ☒ Top ☒ Show Ghosted
☒ Preview Hull
☐ Preview Sections
☐ Define Custom Sections ...
☐ Preview Hydrostatics

Create Hull Cancel Save Settings Back To Hull Library

Panels

The hull is made up of strakes (topsides, bottom, and an optional middle strake), each of which is divided up into panels. A new panel is added when you want to transition from a cone to cylinder (or vice versa) or change the height of the apex. The Start Point of a panel is the percentage of the length along the chine curve. Each strake has a single Apex that may be controlled directly (the first apex); apex heights for the other panels are a multiplier of the height of the first apex. Note that the Apex Height multiplier may be negative; for example, it may be desirable to move an apex for the top strake below the chine, if the sheerline has more curvature than the chine (think of the cone "opening up" as it goes from the apex to the chine to the sheer).

Show Panel Labels: This option will show numeric labels on each panel, corresponding to the Panel #.

Create Middle Strake: This option will create a knuckle in the topsides. This knuckle is defined using a plane that is specified with a Height, Trim, and Heel. The surface between the chine and the knuckle is a cylindrical development, using the chine and the Middle Apex (on the Geometry tab), which is trimmed at the Knuckle plane (defined on the Dimensions tab).

Create Chine Flat: This option will create a flat surface between the Inner and Outer chine curves (defined on the Geometry tab). If the program is unable to create the surface for some reason, there will be a gap left which can be closed later using Sweep 2 Rails or other native Rhino tools.

DevHullWizardForm

Description: Default Developable Hull Assistant

Dimensions Panels **Geometry**

Apex Locations

	X	Y	Z	
Top Apex:	9.61512 m	10.5486 m	14.1 m	Place..
Middle Apex:	-15.1 m	-15.7 m	-16.7 m	Place..
Bottom Apex:	-7.6 m	-5.2 m	-4.3 m	Place..

Edit Master Curves

Master Curve Extension Properties

Extension Length: 50 m

Extension Type: Line

☒ Show Apexes and Master Curves
☐ Show Extrusions
☒ Bottom ☒ Top ☒ Show Ghosted
☒ Preview Hull
☐ Preview Sections
☐ Define Custom Sections
☐ Preview Hydrostatics

Geometry

Apex Locations: This allows control of the Top, Bottom, and the optional Middle Apex (if you have selected to create a Middle Strake in the Panels tab). The location may be entered numerically, or graphically by clicking on the Place button. You can see the Apex locations by checking the "Show Apexes and Master Curves" box below. After you complete the move, the focus will return to the dialog box.

Edit Inner Curve: This button allows you to edit control points on the Inner Curve (inner chine), if you have checked the Create Chine Flat box on the Panels tab. If you have not defined your own curve (using the Select Inner Curve button), you can edit the default curve. Note that you should have Planar editing mode on (at the bottom of the Rhino screen); otherwise when you edit a control point it will be projected into the CPlane. When you have finished editing, right click or hit ESC to return to the dialog.

Edit Outer Curve: Same as above, but for the Outer Chine curve (or if there is no chine flat, the only chine curve).

Select Inner/Outer Curve: These buttons allow you to select a curve that you have drawn in Rhino as the Inner/Outer chine curve. Try to limit the number of control points to 10 or fewer; otherwise you will see a drop in computation speed.

Master Curve Extension Properties: The Extension Length and Type affect the Inner and/or Outer Curves. The length extends both fore and aft of the Inner and Outer curves, and this defines the length of the extruded surfaces from which the hull is trimmed. The Extension Type may be Line, Arc, or Smooth. By checking the Show Extrusions box, you can see the effect of both of these variables.

8.3.2 Creating a Single Chine Hull

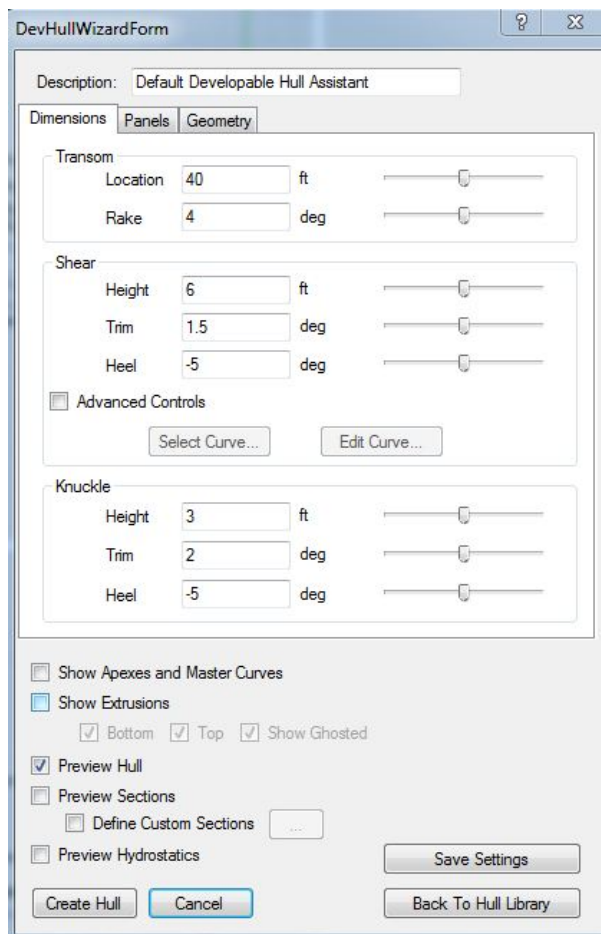
This section will describe the steps to create a developable single chine hull, using the default hull assistant settings as a starting point. The images below show the Orca3D Viewports, which are set using the [Orca3D Viewports toolbar button](#)⁹⁶.

Note that while in the Assistant, the mouse wheel will not work for zooming. You must use CTRL-Right-Click.

Step 1: Set the Orca3D Viewports. Turn on Planar at the bottom of the Rhino screen.

Step 2: Set the units, in the File/Properties dialog. The default hull assistant will create a hull that is 40 units long. In the example below, we will create a hull that is approximately 40 feet long.

Step 3: Start the Developable Hull Assistant, and check Preview Hull.



Step 4: On the Panels tab, uncheck "Create Middle Strake" and uncheck "Create Chine

Flat."

The screenshot shows the 'DevHullWizardForm' dialog box with the 'Geometry' tab selected. The 'Description' field contains 'Default Developable Hull Assistant'. The 'Top Strake' table has 5 panels with start points from 0 to 0.85 and apex heights of 1, 1, 1, 0.75, and 0.55. The 'Bottom Strake' table has 2 panels with start points 0 and 0.85 and apex heights of 1 and 1. Checkboxes for 'Show Panel Labels', 'Create Middle Strake', 'Create Chine Flat', 'Show Apexes and Master Curves', 'Show Extrusions', 'Preview Hull', 'Preview Sections', and 'Preview Hydrostatics' are visible. The 'Show Extrusions' sub-section has 'Bottom', 'Top', and 'Show Ghosted' checked. Buttons for 'Create Hull', 'Cancel', 'Save Settings', and 'Back To Hull Library' are at the bottom.

Panel #	Start Point (%)	Shape	Apex Ht
Panel 1	0	Cylinder	1
Panel 2	0.1	Cone	1
Panel 3	0.35	Cylinder	1
Panel 4	0.6	Cone	0.75
Panel 5	0.85	Cone	0.55

Panel #	Start Point (%)	Shape	Apex Ht
Panel 1	0	Cone	1
Panel 2	0.85	Cylinder	1

☐ Show Panel Labels
☒ Create Middle Strake
☒ Create Chine Flat

☐ Show Apexes and Master Curves
☐ Show Extrusions
 ☒ Bottom ☒ Top ☒ Show Ghosted
☒ Preview Hull
☐ Preview Sections
 ☐ Define Custom Sections ...
☐ Preview Hydrostatics

Create Hull Cancel Save Settings Back To Hull Library

Step 5: On the Geometry tab, adjust the Top and Bottom Apex values as shown below (either graphically using the Place button, or by typing in the values). Set the Extension Length to 25 feet, and the Extension Type to Smooth.

DevHullWizardForm

Description: Default Developable Hull Assistant

Dimensions | Panels | Geometry

Apex Locations

	X	Y	Z	
Top Apex:	1.89 ft	7.72 ft	13.06 ft	Place...
Middle Apex:	-15.1 ft	-15.7 ft	-16.7 ft	Place...
Bottom Apex:	-2.4252 ft	-5.2 ft	-4.1302 ft	Place...

Edit Master Curves

Green square: Edit Inner Curve, Select Inner Curve

Orange square: Edit Outer Curve, Select Outer Curve

Master Curve Extension Properties

Extension Length: 25 ft

Extension Type: Smooth

☒ Show Apexes and Master Curves

☐ Show Extrusions

☒ Bottom ☒ Top ☒ Show Ghosted

☒ Preview Hull

☐ Preview Sections

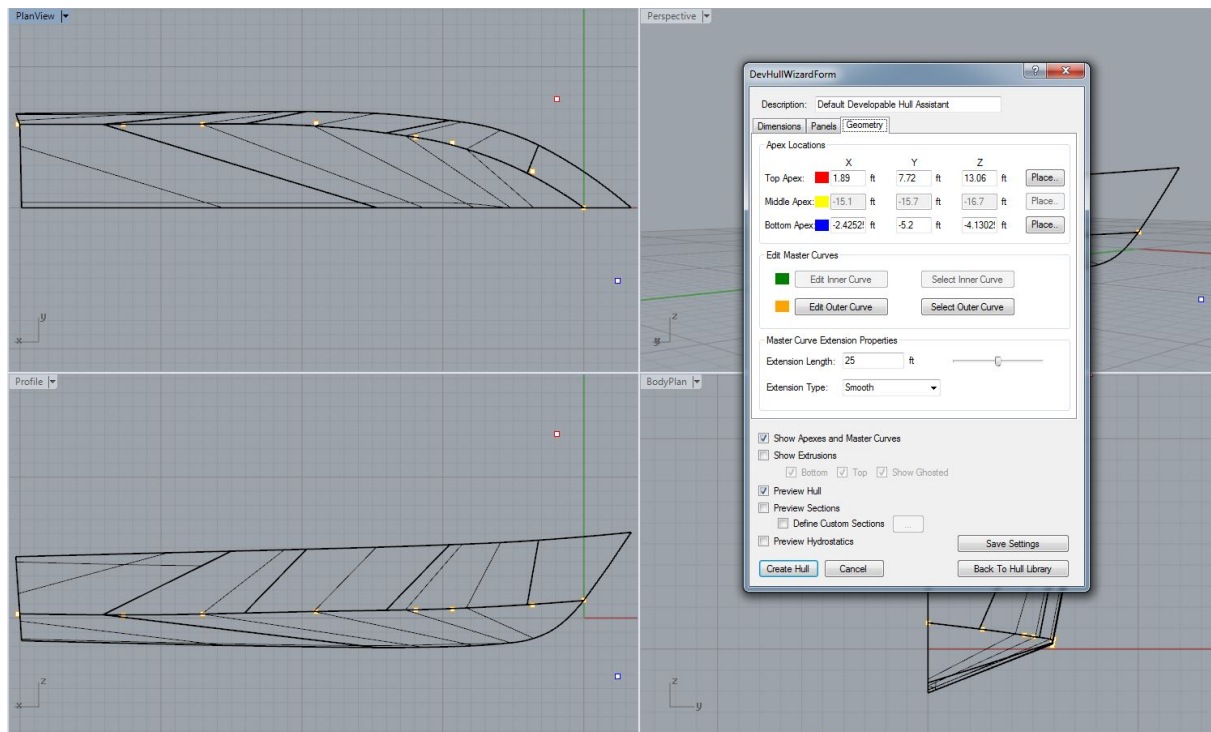
☐ Define Custom Sections

☐ Preview Hydrostatics

Save Settings

Create Hull Cancel Back To Hull Library

Step 6: The final step is to edit the control points on the Outer Curve (chine), as shown in the image below:



Notice that pulling up the aft end of the chine will create rocker in the bottom of the hull. Pulling in the aft end of the chine in Plan View will create tumble home in the topsides.

When moving the Apexes, experiment with moving them in all three dimensions to see the effect. They don't need to be as close to the hull as shown in this example; try moving the Top Apex to -32, 26, 86.

To see the underlying surfaces that are being created, check the Show Extrusions box. Experiment with the different types of extensions. Note that you can also manually extend the curve by moving the control points beyond the centerplane and farther aft than the transom. Then you could set the Extension Length to 0.

While in the Assistant, you don't have access to Rhino's fairing tools, so you have to visually fair the Outer Curve. Instead, you can draw the chine curve before starting the Assistant, and use the Select Outer Curve button to set it as the Outer Curve (which you can then edit in the Assistant if you need to).

In this example, we used the planar sheer option in the Dimensions tab. This means that the sheerline is created by trimming the extruded surface at a plane that is defined by the Sheer height, Trim angle, and Heel angle. Experiment with these settings to see how they affect the sheerline. Alternatively, you can draw a sheer curve before entering the Assistant, and with the Advanced Controls under Sheer, you can select this curve to define the sheerline in profile. The curve that you select is projected horizontally to intersect and trim the extruded surface. So, the hull's sheerline will match your curve in Profile view, but may or may not match in Plan View.

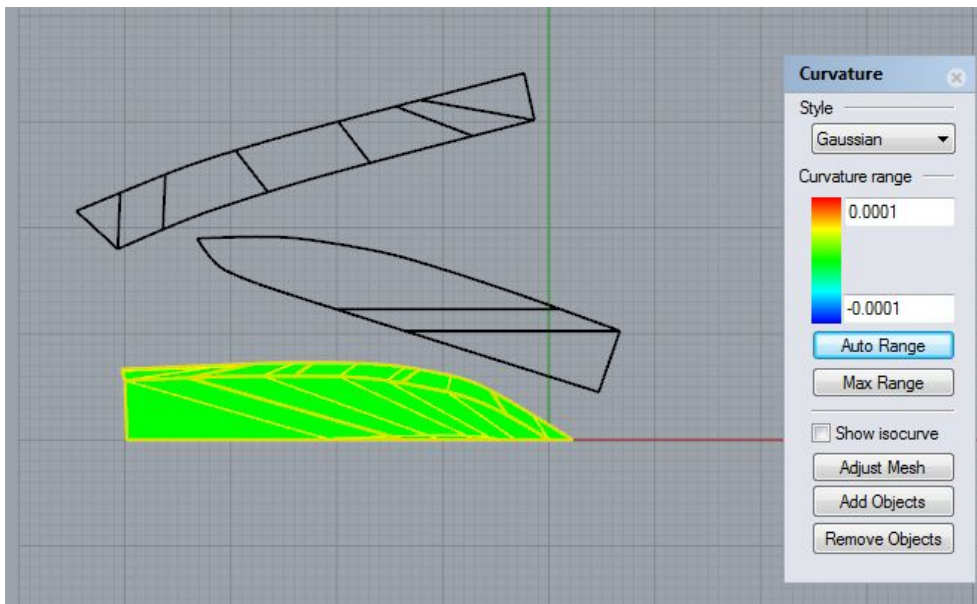
8.3.3 Unrolling a Hull

First, to convince yourself that the hull is developable, select all or part of it, and in the Analyze menu select Surface/Curvature Analysis. Set the curvature style to Gaussian. When you set the range to Auto, you will see some non-green (i.e. non-zero) panels, but you'll also notice that the values are very, very small (e.g., 10^{-33}).

To flatten the hull surfaces after you have created a hull, follow these steps:

1. Join all of the panels in a each strake into a polysurface (i.e., one polysurface for the bottom, one for the chine flat, and one for the topsides (or 2 if you have a knuckle)).
2. Define any curves (e.g., frames) that you'd like to see on the unrolled plates, using the Orca3D Sections function.
3. Run the Rhino command UnrollSrf; select the Explode option to No.
4. Select the polysurface to unroll.

The image below shows a hull with curvature analysis, and the unrolled strakes.



8.3.4 Other Geometries

If your hull does not fit into the topology of the Developable Hull Assistant (for example, there is a knuckle in the bottom surface between the centerline and the chine), you can always create part of the hull with the assistant, and then use Rhino's Loft-Developable to build onto the hull.

8.4 Foil Assistant

Toolbar	
Menu	Orca3D > Hull Design > Foil Assistant
Command	OrcaCreateFoil

The Orca3D Foil Wizard automates the process of creating foil-shaped surfaces, such as keels and rudders. The user selects the foil type, various dimensions, and options such as capping the tip or including a bulb, and the foil is automatically created.

In addition to the foil types that are contained in the program, you may enter your own foil offsets into a comma-separated value (.csv) file (normally done with Excel). A good source of offsets for a large number of airfoils is the University of Illinois website: https://m-selig.ae.illinois.edu/ads/coord_database.html

Another good source is the Airfoil Tools website: <http://airfoiltools.com/airfoil/details?airfoil=naca0010-il>

A sample csv file is located in the installation directory, in a folder called "Sample Data." By default, this is c:\Program Files\Orca3D\Sample Data\AirfoilData.csv.

The format of the file is as follows:

For each foil there are two rows:

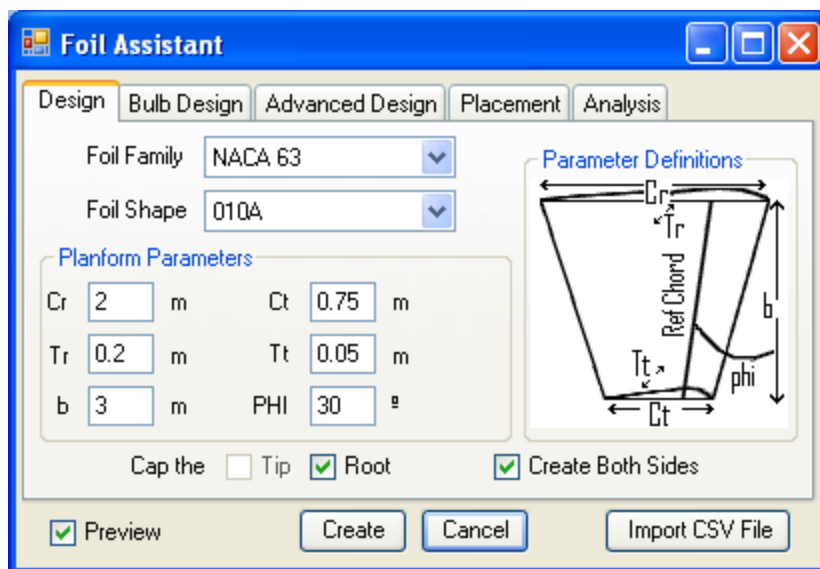
First row: family name, longitudinal offsets beginning at 1 (the trailing edge), decreasing to 0, then back up to 1

Second row: foil name, half-breadths for each longitudinal offset

For example, the data would look as follows in Excel (just the first 7 columns are shown; this particular foil has 52 columns)

NACA 63	1	0.95	0.9	0.85	0.8	etc.
010A	0	0.00525	0.0103	0.01535	0.0204	etc.

To use the data, open the Foil Assistant, and click on Import CSV file. After the file is read, you should find your foils in the drop down lists of Foil Family and Foil Shape.

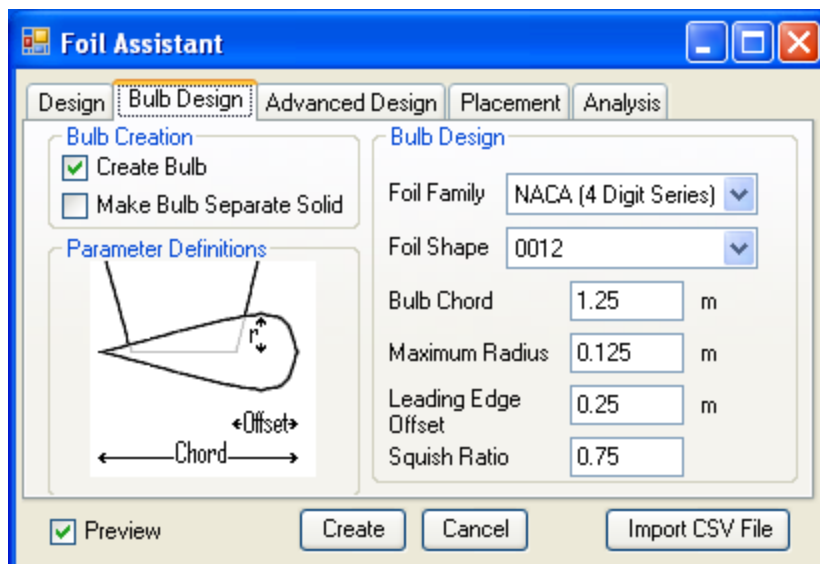


Foil Assistant Design Parameters:

- Cr - Root Chord
- Tr - Root Thickness
- Ct - Tip Chord
- Tt - Tip Thickness
- B - Span
- Phi - Reference chord sweep angle (from vertical)

Clicking the Preview button will display the foil as you define the parameters.

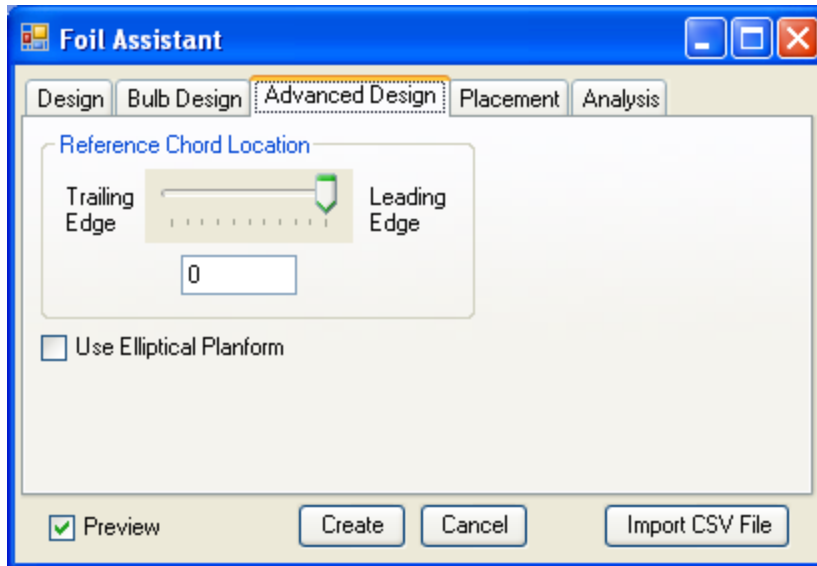
If you want to include a bulb, go to the Bulb Design tab:



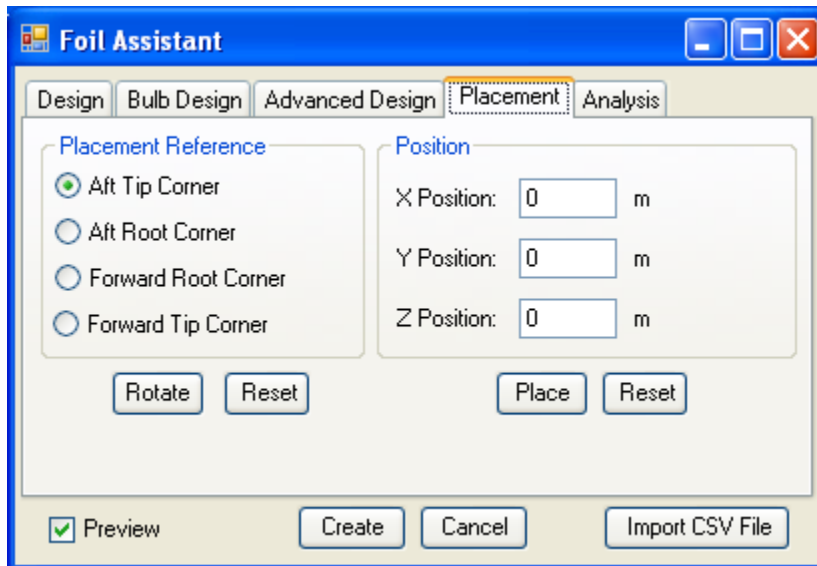
Bulbs are created by revolving an airfoil, and then "squishing" (scaling vertically). If the bulb will be manufactured from a different material than the keel, check "Make Bulb Separate Solid."

The sweep angle of the keel (phi) is defined at the reference chord location, which is the

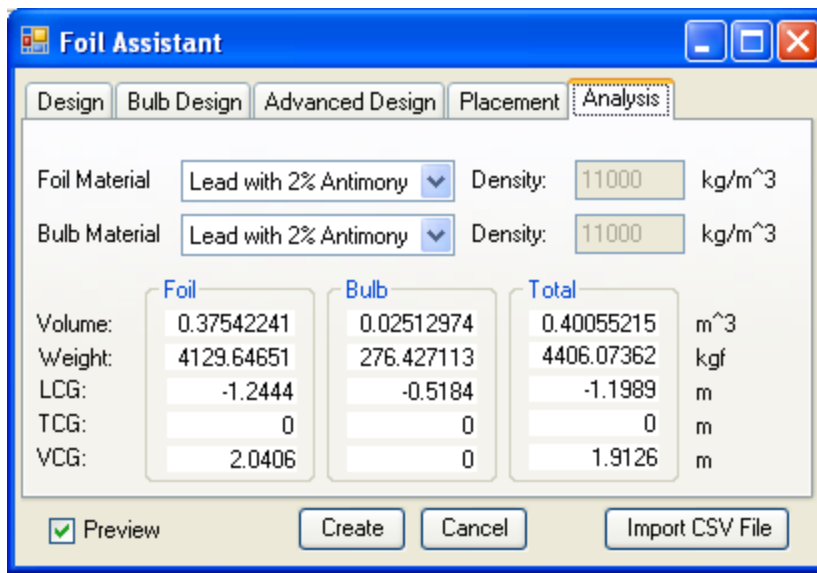
leading edge by default. In the Advanced Design tab, you can move the reference chord to a different location (0 is the leading edge, 1 is the trailing edge). You also have the option of specifying an elliptical planform.



The location of the foil may be specified by coordinates, with four options for the reference point. The foil may also be rotated or placed graphically.



The Analysis tab computes the volume and centroid of the foil, the bulb, and the combination. Making use of Orca3D's Weight/Cost functionality, the weight of the foil and bulb can be automatically computed, based on materials in the Material Library.



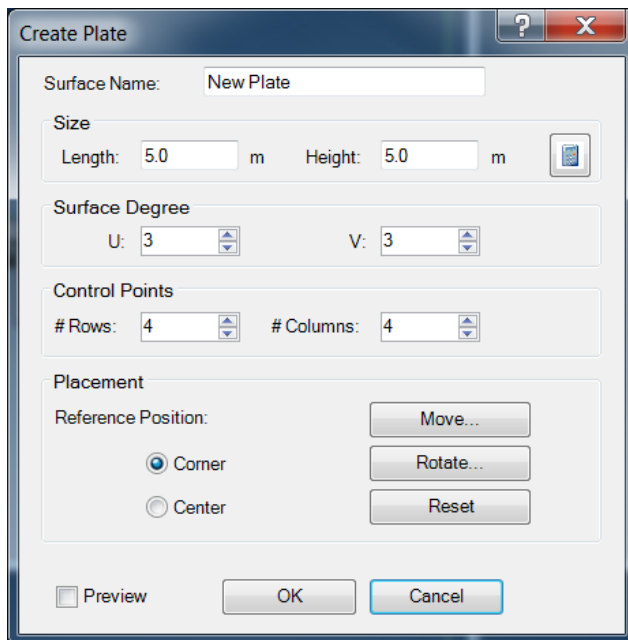
Once a foil has been created, it can be edited just like any other surface object in Rhino.

8.5 Create Plate

Toolbar	
Menu	Orca3D > Hull Design > Create Plate
Command	OrcaCreatePlate

Often a hull design is begun using an existing model, importing a hull from another program, or one of the Hull Assistants. But sometimes it is easiest to begin with a "flat plate" of [NURBS](#) surface, and then "sculpt" that flat surface into the desired shape. While Rhino has a function for creating a rectangular surface, it does not give you control over the degree and number of rows and columns.

The Orca3D Create Plate function creates a flat surface, with user-specified dimensions, degree, and number of control points. To start this function, click on the Create Plate icon, select Create Plate from the Orca > Hull Design > Create Plate menu, or type the OrcaCreatePlate command.



The length and height may be specified graphically, by clicking on the icon to the right of values, and then dragging a box in the desired viewport.

By default, the degree is 3 (cubic) in both directions. In general, cubic surfaces are the best suited for hull design and fairing. However, if you know that your surface will be flat, change the degree to 1 in both directions.

Next, you may specify the number of control points. Note that this must be at least 1 greater than the degree in that direction.


Finally, you may place and rotate the surface, using either the corner or the center as the reference. Check the Preview box to see the surface as you change the various parameters.

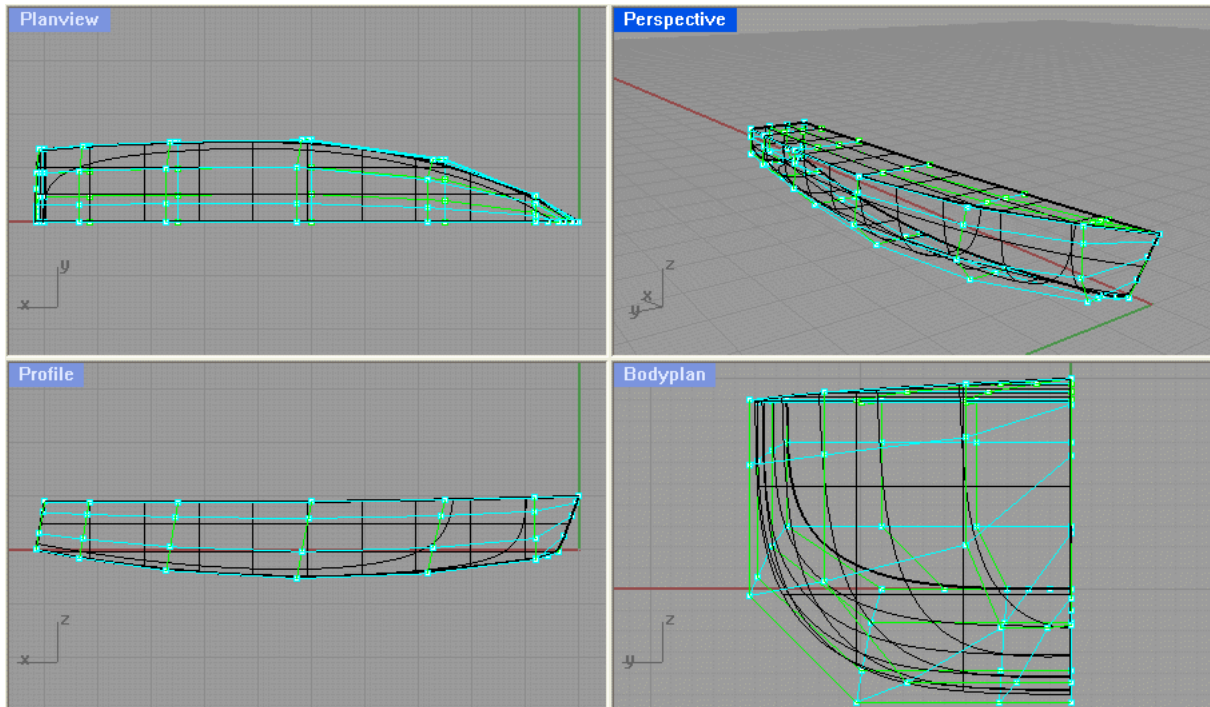
8.6 Moving Control Points

When hulls are modeled by the direct manipulation of control points, it's important to be able to easily and quickly drag the control points to "sculpt" the shape of the hull. To edit the shape of a surface, turn on its control points, and drag them to "stretch" the surface as desired. Rhino has control points that may be moved, but to see the [sections](#)^[236] update in real time, you should use the [Orca Control Points](#)^[121]. (To place control points numerically, see the [OrcaMove](#)^[197] command.)

Turning on Orca Control Points

Toolbar	
Menu	Orca3D > Hull Design > Orca3D Control Points On
Command	OrcaPointsOn

1. Start the command from the toolbar, menu, or command line.
2. Select the surface(s) you wish to edit, and hit Enter.
3. The control points for the surface(s) will be shown. Orca control points, and the lines that connect them, are drawn differently than the standard Rhino control points. You may control the color of the lines in the control polygon in the Orca Properties dialog (). By default, control lines in the U direction (longitudinal, in general) are drawn in cyan, and the V direction (transverse, in general) are drawn in green.




You may select and move the control points in any view, just as you would other Rhino objects. If you have defined sections, you'll see them update as you move the control point(s). In real-time mode, the sections are computed from a temporary mesh, but when you put the point(s) down, the sections are re-computed in a smoother, more accurate manner. If you have turned on real time hydrostatics (see [Design Hydrostatics](#) ^[270]), you'll see a control showing those values updating as you move the control point(s).

Note that if you have Osnaps turned on, the control points will honor those (End, Near, etc.). This can sometimes lead to unexpected results. Once you begin moving a control point, it can be helpful to press and hold the ALT key, temporarily disabling the Osnaps.

When moving points in the Perspective view, it's important to know what plane the point is moving in, since it's a 3D view. To make this process easier, Orca3D has the concept of Edit Planes. These are constraint planes, so that as you move a control point in the Perspective viewport, it will move parallel to the Edit Plane. For example, if the Edit Plane is chosen to be Station, the control points will move transversely and vertically, but not longitudinally. If the Edit Plane is set to Buttock, the point will move longitudinally and vertically, but not transversely. In the image above, the Edit Plane is set to Waterplane, so that points will move longitudinally and transversely.

OrcaEditPlane

Toolbar	
Menu	n/a
Command	OrcaEditPlane

8.7 Inserting and Removing Control Points

Inserting and Removing Control Points

Toolbar	
Menu	Orca3D > Hull Design > Insert Net
Command	OrcaInsertNet

Toolbar	
Menu	Orca3D > Hull Design > Remove Net
Command	OrcaRemoveNet

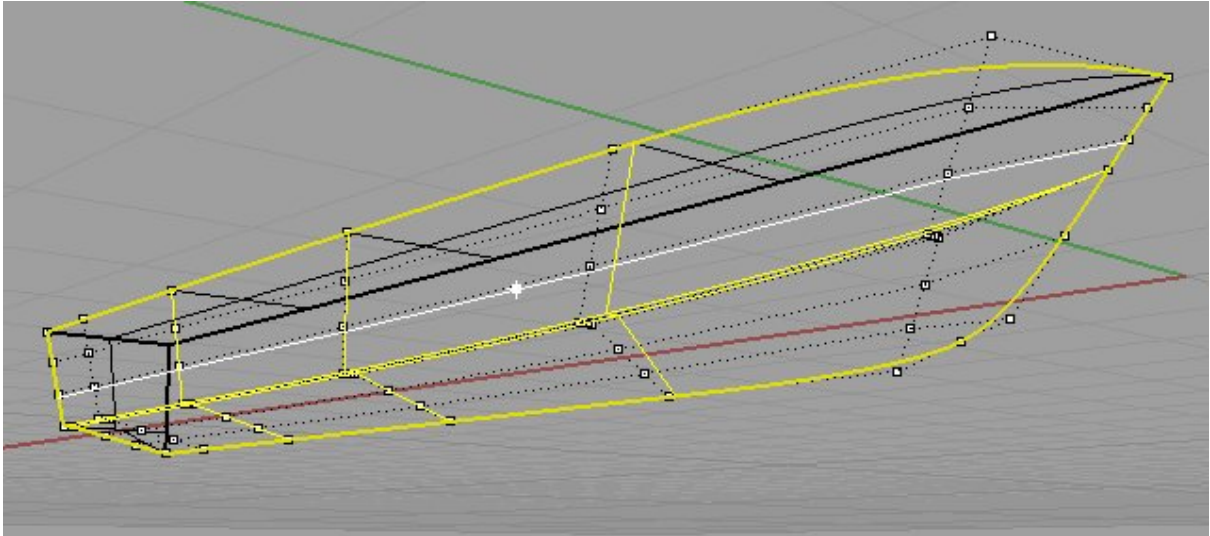
Often when modeling a hull, you find that you either need more rows or columns of control points in your control net, or you need to remove a row or column of control points. Rhino has commands to do this, but the Orca3D commands will maintain the uniformity of the knot vector if possible, leading to a higher quality surface. Therefore, there are similar commands in Orca to add or remove control points.

Inserting Control Points

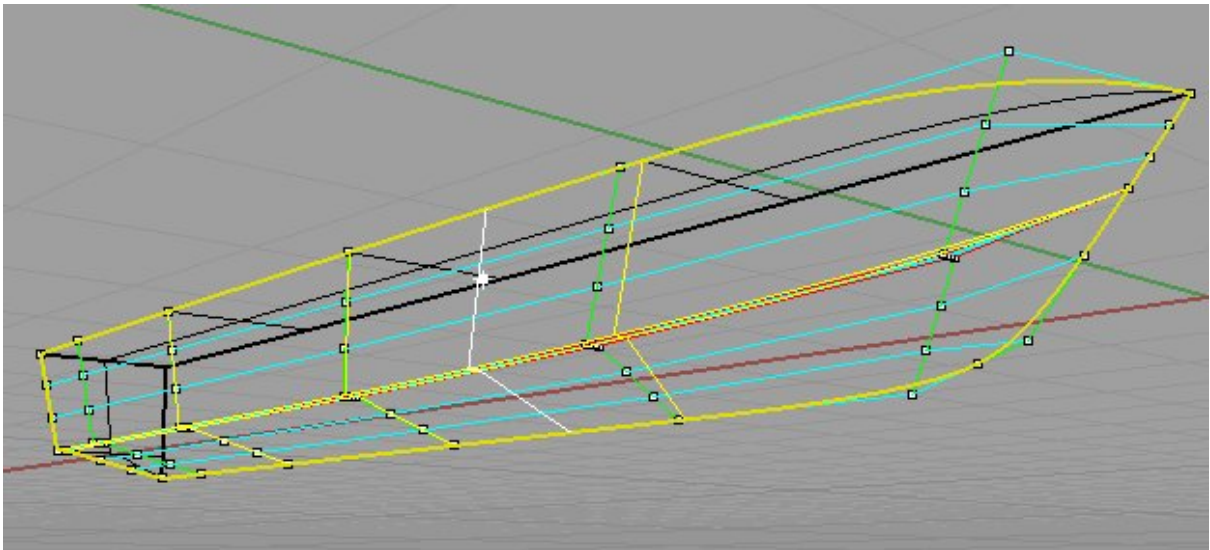
You can insert either a row or column of control points into the control net for your surface. Start the command, and select the surface. If the Orca3D or Rhino control points were not already on, the Rhino control points will be shown. In the command line, there are two options to select:

- **Direction=U (or V):** U is generally the row (longitudinal) direction, and V is generally the column (vertical) direction. Click on Direction to toggle if desired.
- **Midpoint=On (or Off):** the location of the new row or column is specified by dragging the cursor. If you wish it to be exactly midway between two existing rows or columns, click Midpoint to toggle this option on, and the cursor will then snap to the midpoint.

If you try to insert a row or column within 10% of the edge of the surface, you will be prompted to confirm that you want to do this, because having control points near an edge can make it difficult to fair the surface.



Inserting a Net in the **U** Direction (Rhino control points shown)



Inserting a Net in the **V** Direction (Orca3D control points shown)

Removing Control Points

You can remove either a row or column of control points. Start the command, and select the surface from which control points will be removed. There is a single option:

- Direction=U (or V): U is generally the row (longitudinal) direction, and V is generally the column (vertical) direction. Click on Direction to toggle if desired.

You cannot remove the rows or columns on the edge of a surface.

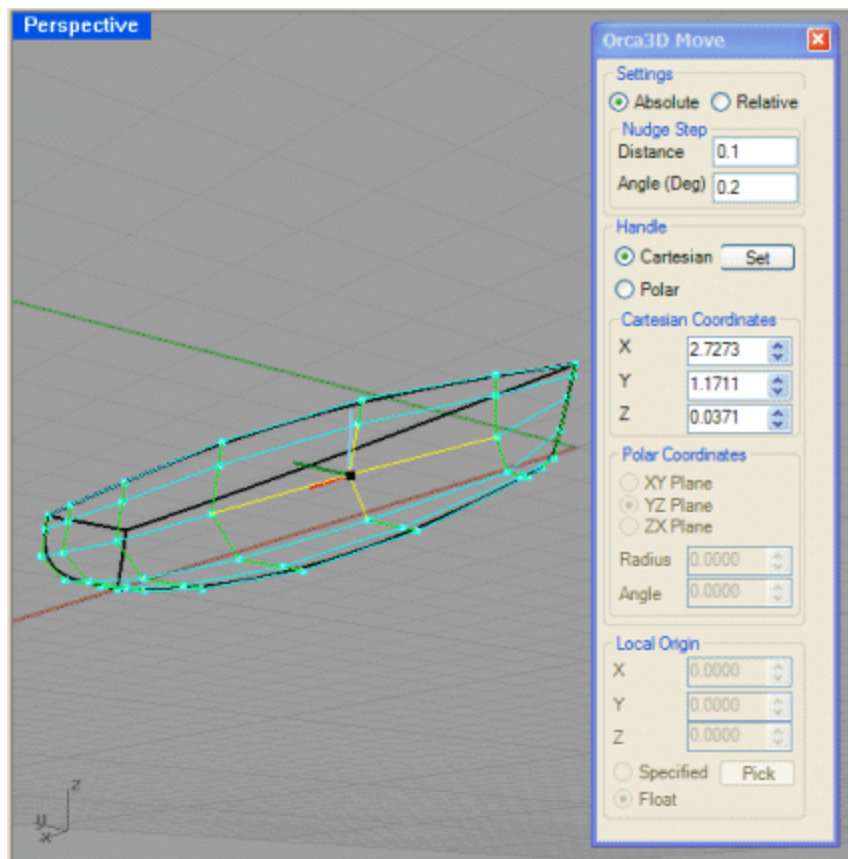
8.8 OrcaMove

OrcaMove Control

Toolbar	
Menu	Orca3D > Hull Design > Orca Move
Command	OrcaMove

When hulls are modeled by the direct manipulation of control points, it's important to be able to easily and quickly drag the control points to "sculpt" the shape of the hull. But it is also important to be able to very precisely place the control points, or make "fine-tuning" adjustments to tweak the hull shape. The Orca3D Move Control allows you to easily enter the coordinates of an [Orca Control Point](#) ¹²¹ (it will not work on standard Rhino control points) or other objects in your model. Multiple Orca Control points and/or objects can be moved together, and the coordinates may either be Absolute (World) or Relative. To make it easier to precisely set angles (such as a deadrise angle), you may also use a Polar coordinate system.

Executing the *OrcaMove* command displays the control:



When you select a point (remember, this command only works on [Orca Control Points](#)¹²¹, not Rhino control points), a small coordinate gnomon is drawn on the point, and its coordinates are shown in the X, Y, and Z fields. At this point, you can simply type in values, or use the up and down spin buttons to move the control point (this applies to moving objects as well). The spin buttons will change the values by the "Nudge Step" value shown near the top of the dialog.

The coordinate gnomon indicates the location of the "handle." The handle is the point whose coordinates are shown in the fields, and normally is just the point that you are moving. However, you can select multiple control points, and the last point that you select will be the handle point. When you change the coordinates, the other control points will shift by the same amount. If you wish to change the handle to another location (it can be any location, not just another control point), click on the Set button, and select the point graphically, or type the X, Y, and Z coordinate of the handle in Rhino's command line.

Relative coordinates are useful when you want to know or specify how far to move a point from its current location. To do this:

1. At the top of the control, click on the Relative radio button.
2. At the bottom of the control, click on the "Float" radio button. With "Float" enabled, the Local Origin will always match the Handle location.
3. Click on the control point to be moved, and enter the change in X, Y, and/or Z in the field or use the spin buttons.

Relative coordinates can also be used to place an Orca Control Point relative to another control point or object in your model. For example, you might wish for two control points to have the same Y value. To do this, follow these steps:

1. At the top of the control, click on the Relative radio button.
2. At the bottom of the control, click on the "Specified" radio button, then the Pick button
3. Click on the control point that has the Y value that you want. This is now the Local Origin (you may also simply enter the X, Y, and Z values of the Local Origin)
4. Select the control point to be moved. Its coordinates relative to the Local Origin will be displayed. Change the Y value to 0, and hit the Tab key or move the focus to another field to update the model

In both Absolute and Relative coordinates, you may switch to Polar coordinates in order to specify the location of a control point or object with a radius and angle. It's important to know that when using Polar coordinates, you are moving the handle in a plane (XY, YZ, or ZX). The distance is the distance between the handle and either the Absolute or Relative origin, projected into the plane where the handle lies, and the angle is the angle between the handle and the Absolute or Relative origin in that same plane.

8.9 Straightening Control Points

Often when modeling a hull or other surfaces, it is useful to be able to arrange control points in a straight line. The OrcaStraightenPoints command will move points into a [straight line in 3D](#)^[199] between two selected points, or in the [2D projection of a straight line](#)^[204].

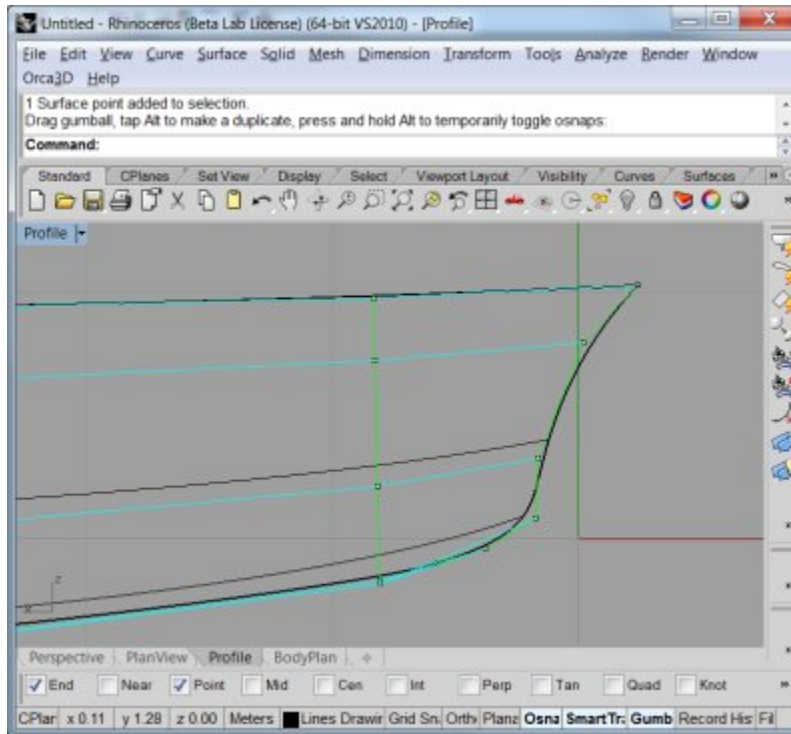
Toolbar	
Menu	Orca3D > Hull Design > Straighten Points
Command	OrcaStraightenPoints

To straighten points into a line in 3D:

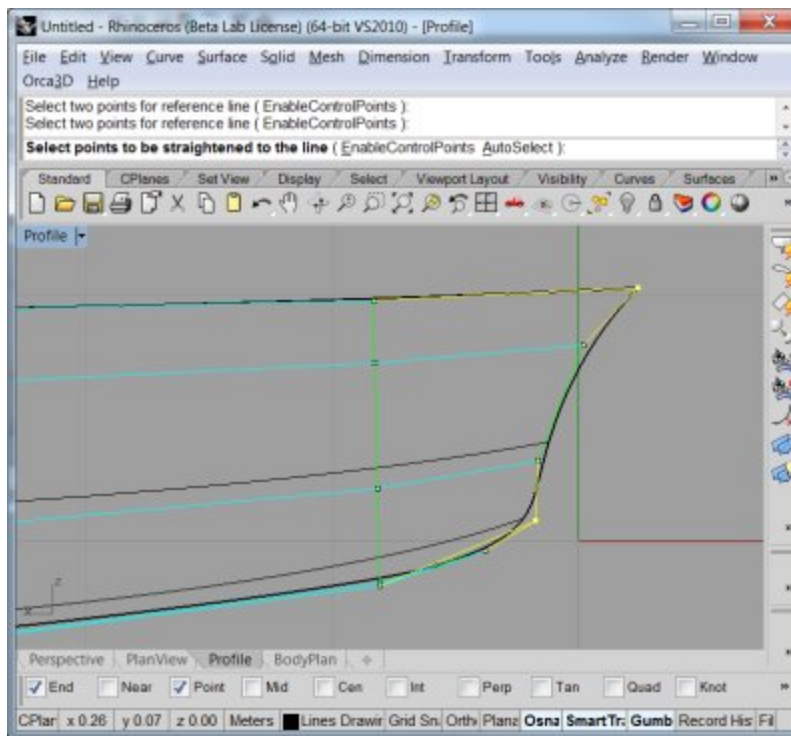
1. Start the OrcaStraightenPoints command (using the icon, menu selection, or by typing the command)
2. If the control points aren't already visible, click on the EnableControlPoints option in the command line
3. Select the two points that will define the line
4. Select the points to be moved into the straight line. If you want to select the control points that are between and on the same column or row as the two points chosen in Step 3, click on the AutoSelect option. Otherwise, select each point graphically. When done selecting the points to be moved, hit Enter or right-click.
5. Hit Enter or right-click to accept the Closest Intersection option. This will move the selected points the shortest distance into a line defined by the two points selected in

Step 3.

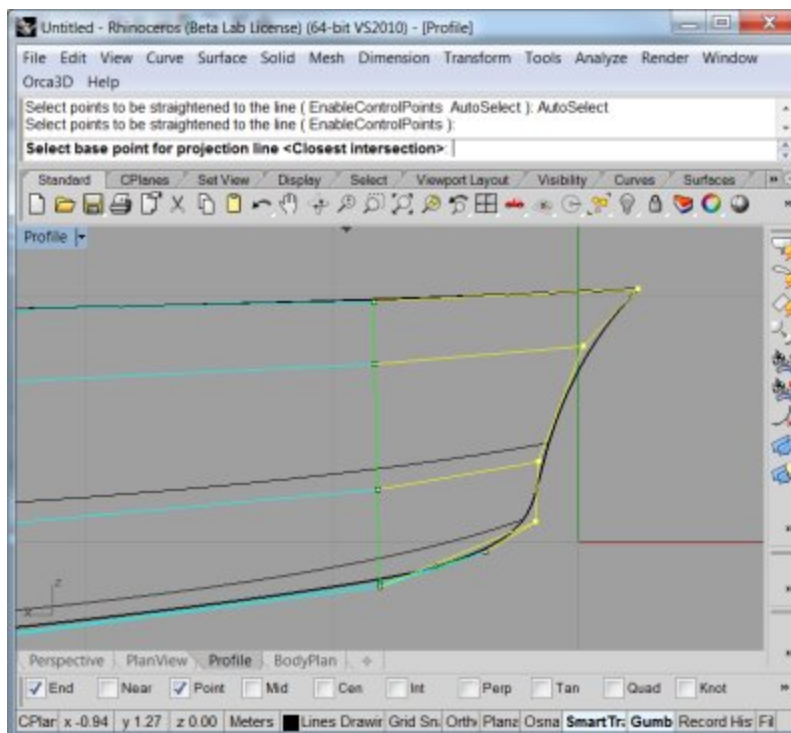
In this first example, we want to move the control points on the stem of this boat into a straight line:



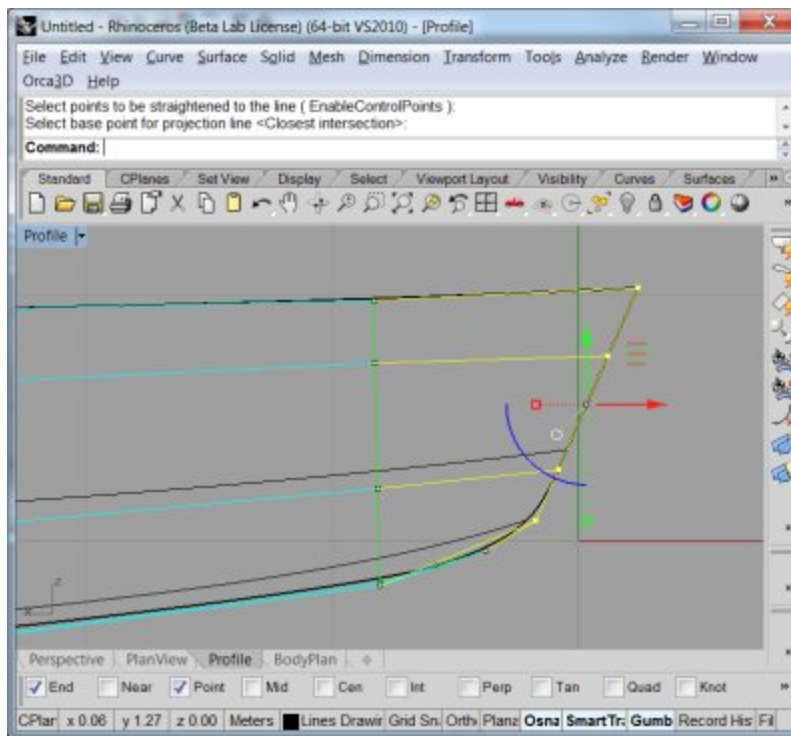
After starting the command, the two points that define the ends of the straight line are selected:



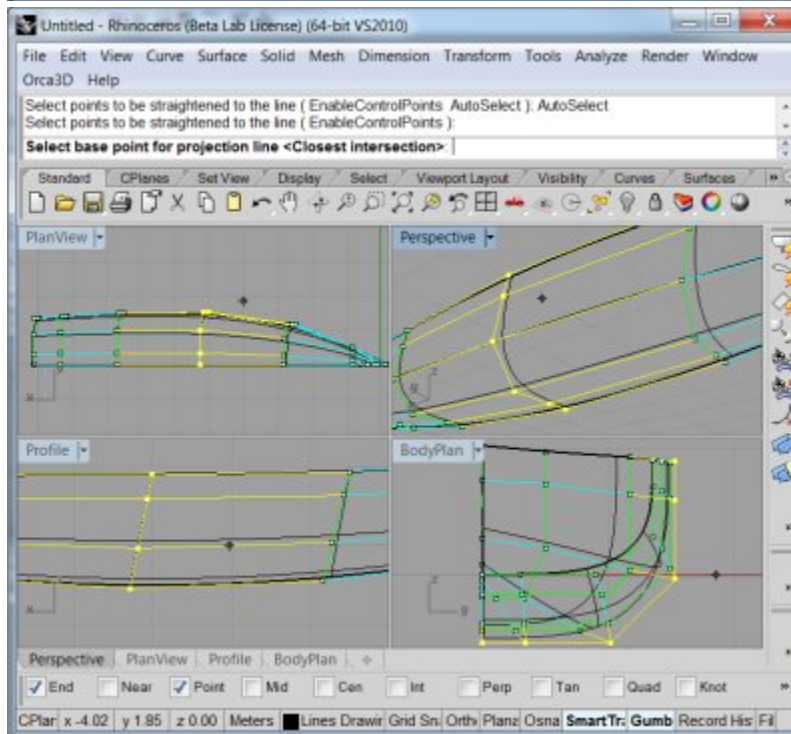
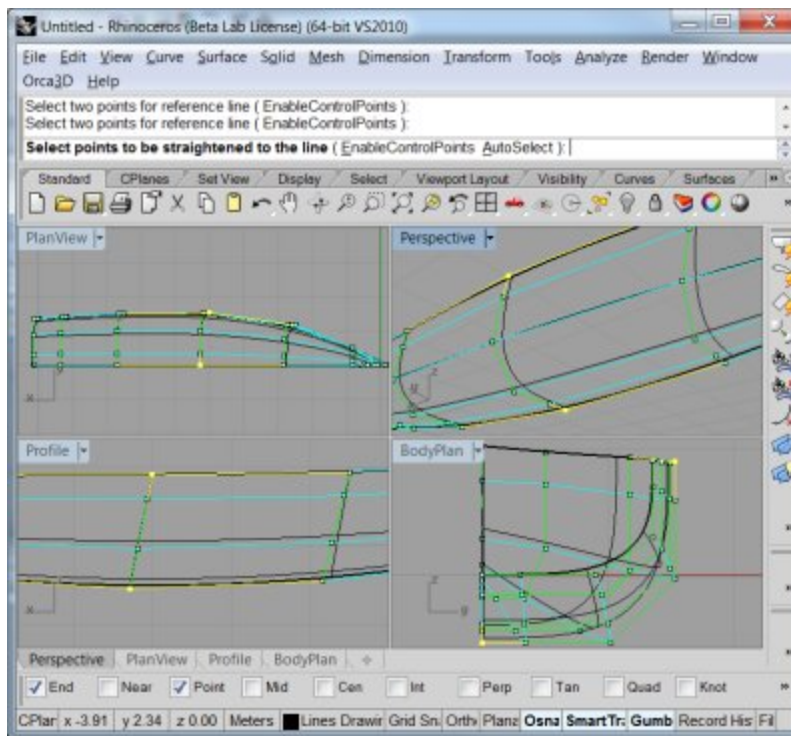
Next, click on AutoSelect to automatically select the points between the two end points, and right click to finish the selection:

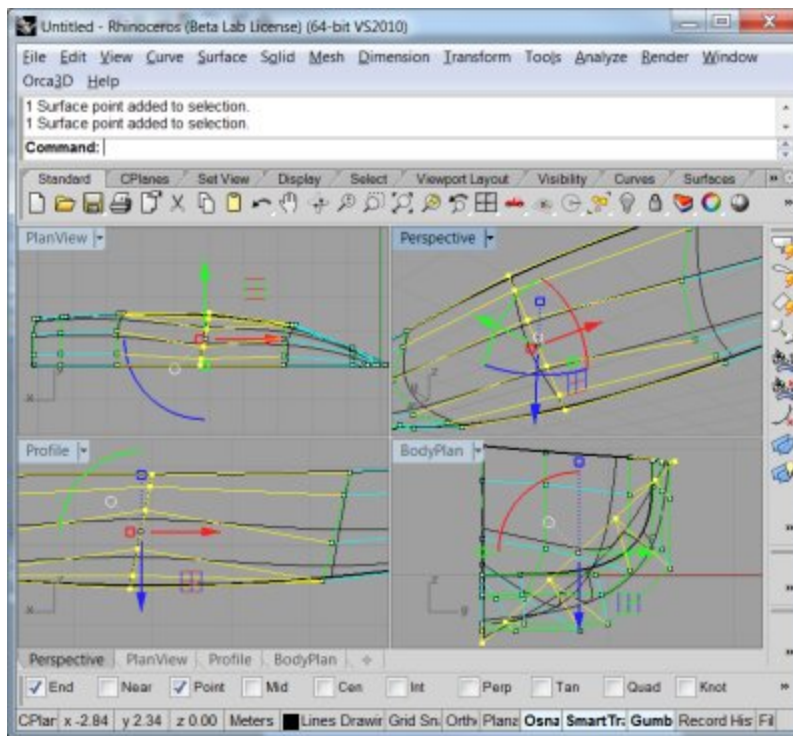


Hit Enter to accept the Closest Intersection option. The points are moved the shortest distance into the straight line.



In the example above, the points were all on the centerplane. Even if the points were not initially coplanar, using the Closest Intersection option will still put the points into a straight line in 3D. In the second example below, similar steps to those above are carried out on a column in the midships region of the hull. This is not a realistic use of the function, but simply demonstrates that the points are moved in 3D, not just the projection of the line in the Profile view.



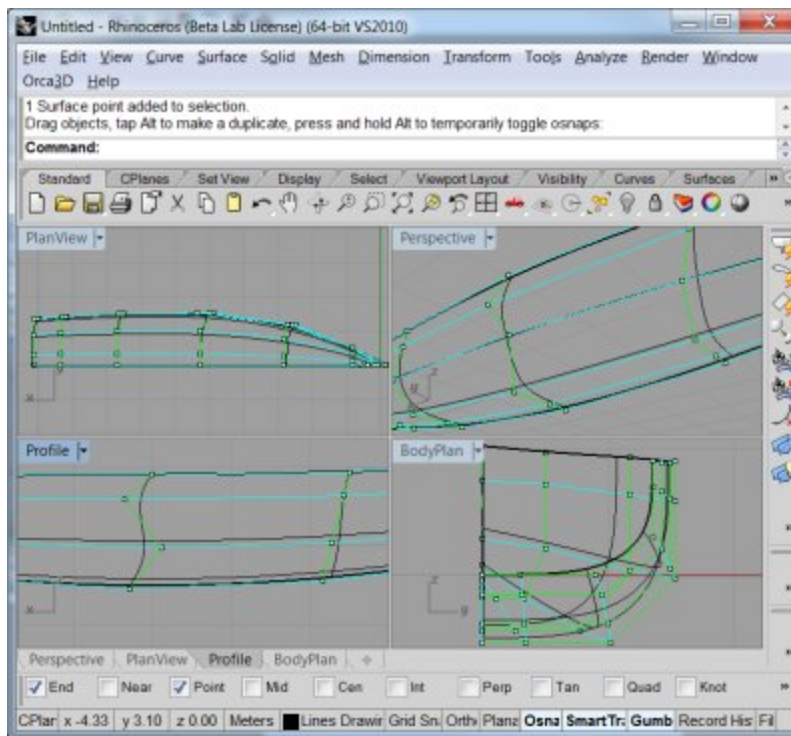


To straighten points into the 2D projection of a line:

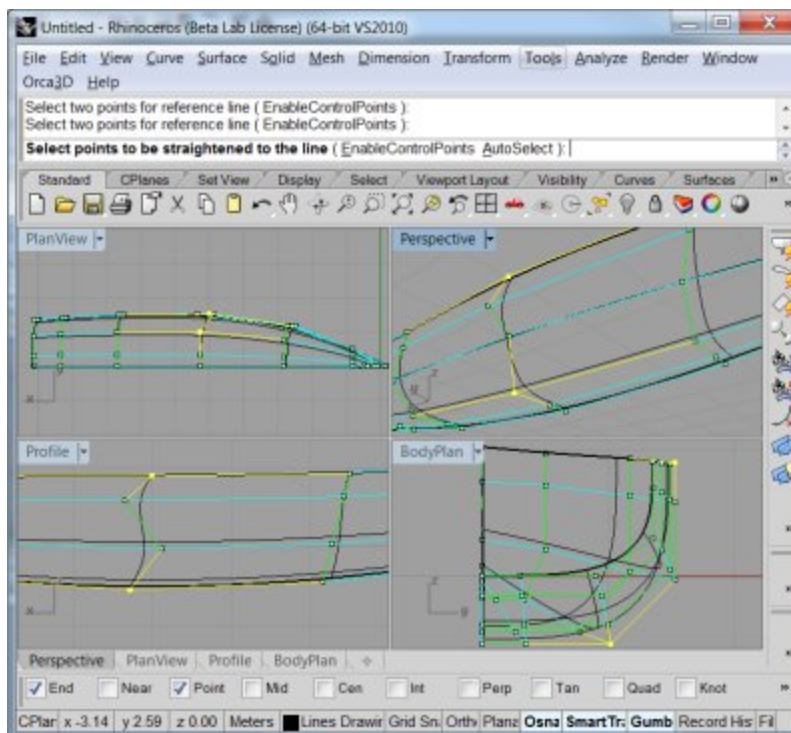
1. Start the OrcaStraightenPoints command (using the icon, menu selection, or by typing the command)
2. If the control points aren't already visible, click on the EnableControlPoints option in the command line
3. Select the two points that will define the line
4. Select the points to be moved into the straight line. If you want to select the control points that are between and on the same column or row as the two points chosen in Step 3, click on the AutoSelect option. Otherwise, select each point graphically. When done selecting the points to be moved, hit Enter or right-click.
5. You are prompted to "Select the Base Point for the Projection Line," and then "Select the Second Point for the Projection Line." The Projection line defines the direction that the points will be moved in order to get to the desired straight line; the points will be moved parallel to this line, rather than to the closest intersection.

When selecting the points for the Projection Line, you are also defining the plane that points will remain in. If you define the Projection Line in one of the orthogonal views (e.g., PlanView, Profile, BodyPlan, Top, Front, Side), the point will not move in the coordinate perpendicular to the viewing plane.

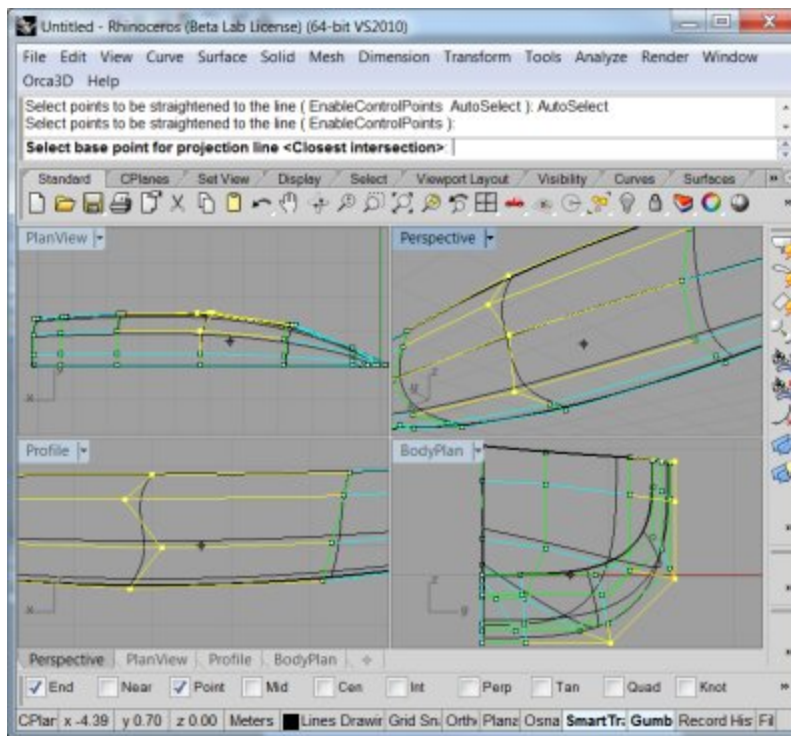
In the following example, the control points on the column are not neatly arranged. We'd like them to be in line in the Profile view, but we don't want their Y (transverse) coordinate to change:



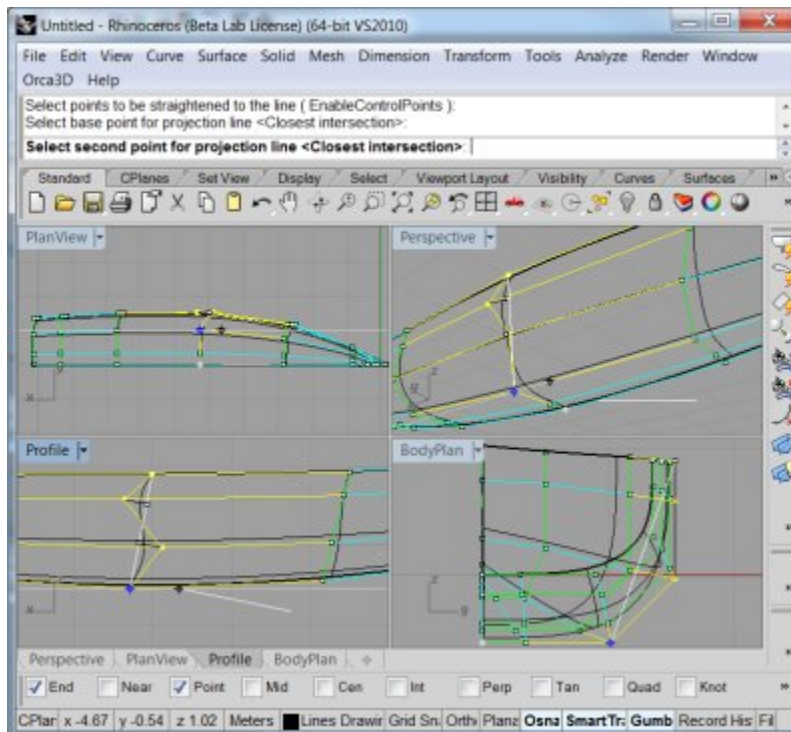
Start the OrcaStraightenPoints command, and select the 2 points that are to be used to define the ends of the line:



Use AutoSelect to select the two points between (or just click on them individually), then hit Enter or right-click:

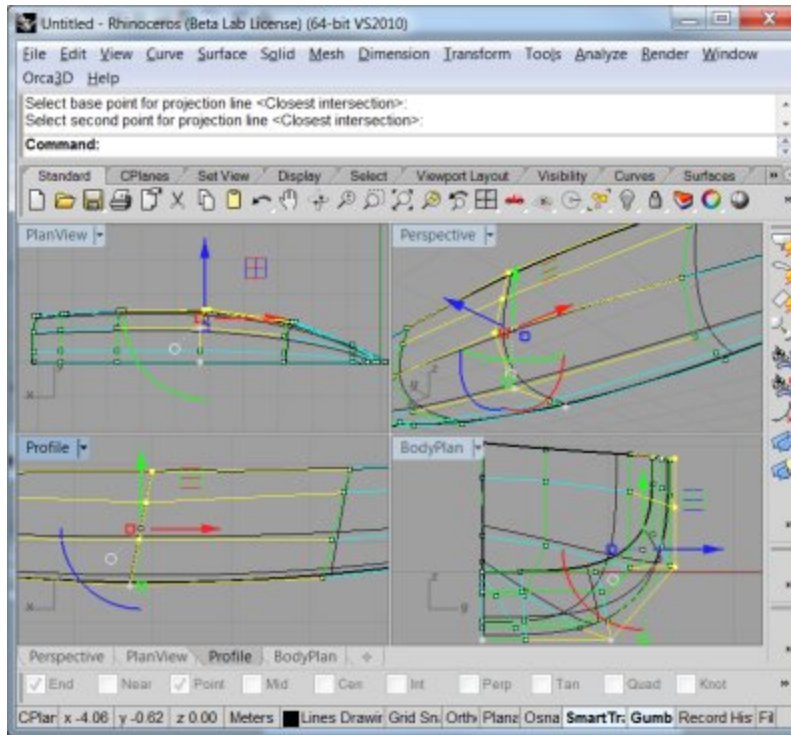


Now, working in the Profile viewport, select the first point for the Projection Line; as you move the second point of the Projection Line around, you'll notice the control points moving in a parallel direction:



If you want the points to move to the Closest Intersection in the 2D projection, hit Enter (be

sure that the Profile view remains as the active view; if you switch to another view, it will change the coordinate that will remain fixed). If you want them to move parallel to the Projection Line, click to put down the second point of the Projection Line:



Notice the difference in the Perspective View between this image, and the last image in the second example above. In this example, the points moved into a 2D projection of a line, without their transverse coordinates changing. In the second example, the points moved in all three dimensions into a line in 3D.

8.10 Inserting a Chine

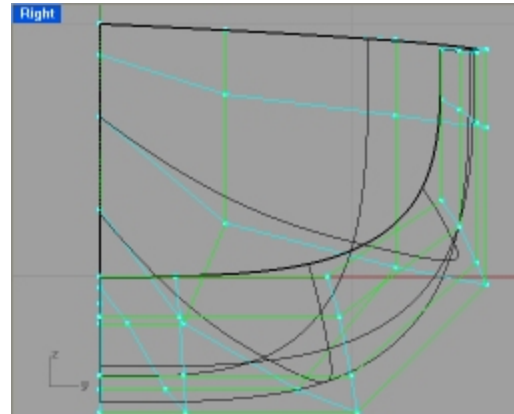
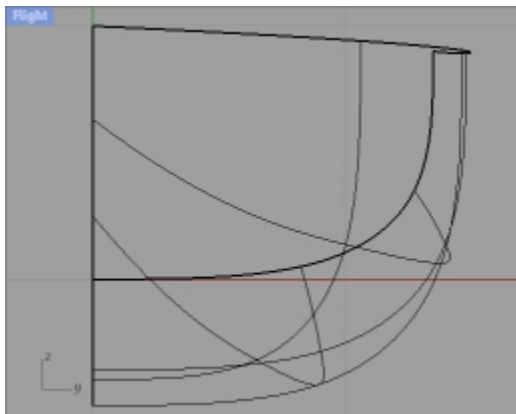
Discontinuities in the hull, such as a chine or knuckle, can be modeled either by splitting the surface, or inserting a discontinuity directly into the surface. Orca3D includes a function to insert a discontinuity directly into a surface, allowing a single surface to be used to model a hull with multiple chines. This makes it easier to edit the hull, since you don't have to worry about keeping two surfaces joined.

Toolbar	
Menu	Orca3D > Hull Design > Insert Chine
Command	OrcaInsertChine

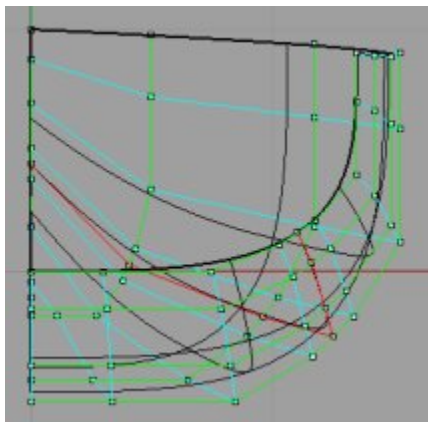
To insert a chine, start the OrcaInsertChine command from the menu or command line. Select the surface into which the chine will be inserted, and then the direction of the chine (generally, the U direction is longitudinal, and the V direction is transverse). Next, select the location for the chine; it is inserted along an isocurve.

To insert the chine exactly on an existing knot, enable Rhino's Intersection Osnap. Your cursor will snap to existing knots on the surface edge, or on intersections of U and V knots.

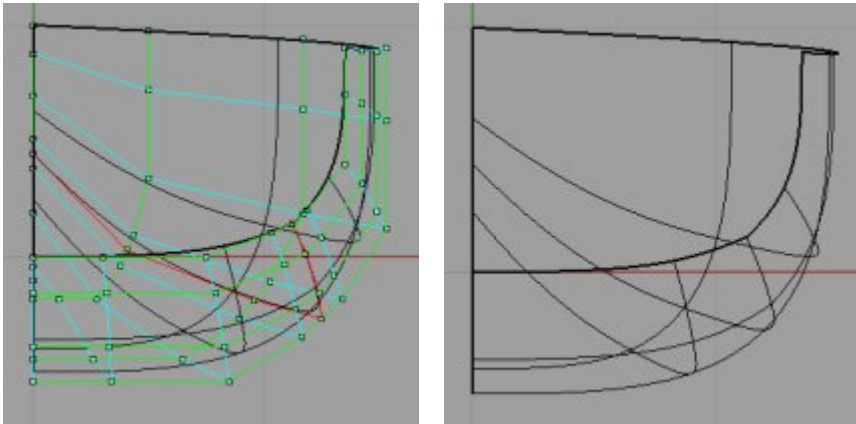
These images show a hull from the sailboat assistant, prior to a longitudinal chine being inserted:



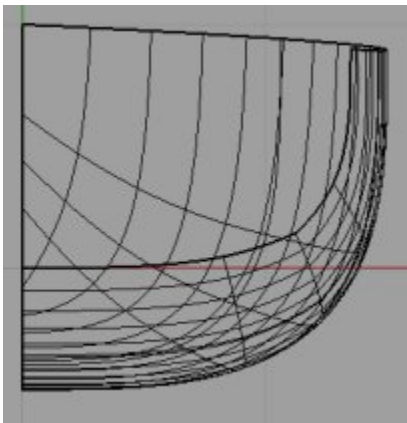
Here the chine has been inserted. Note that while the control net has changed, the shape of the surface has not. If the new control points are not moved, the surface will continue to be smooth.



In the following images, the points around the chine have been edited, but only for the aft three columns in the control net.



Finally, with stations defined, it's easy to see that the chine has developed in the aft portion of the hull, and fades as it goes forward, because the control points around the chine have not been edited since the chine was inserted.



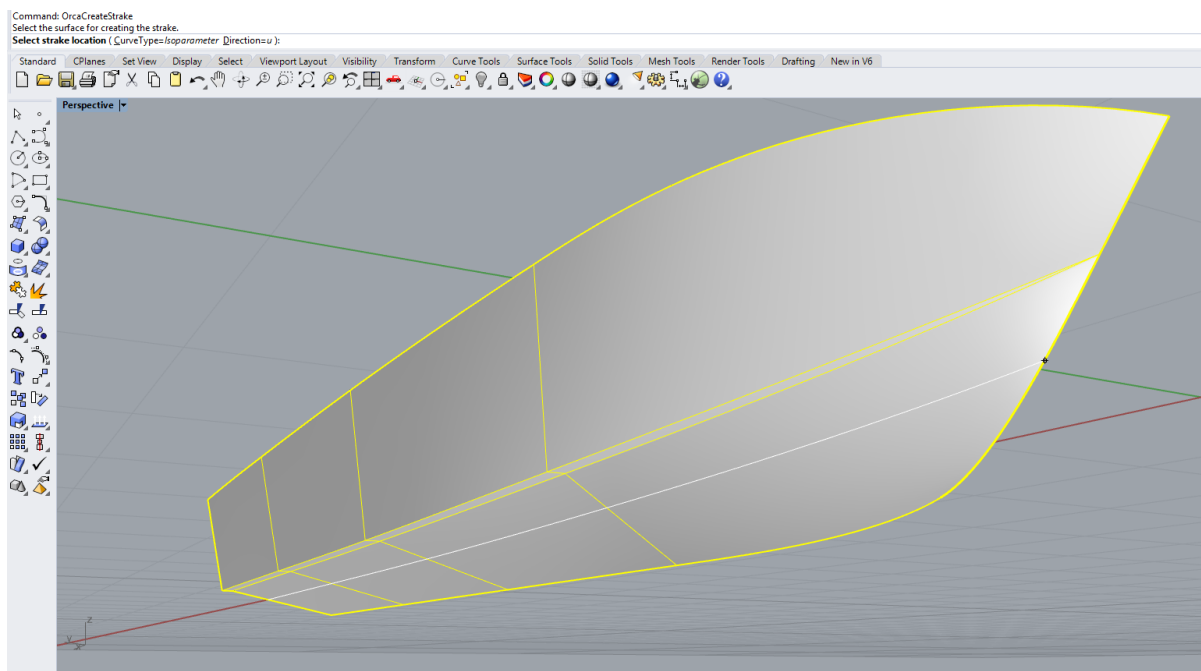
8.11 Creating a Lifting Strake

Toolbar: n/a

Menu: Orca3D > Hull Design > Create Lifting Strake

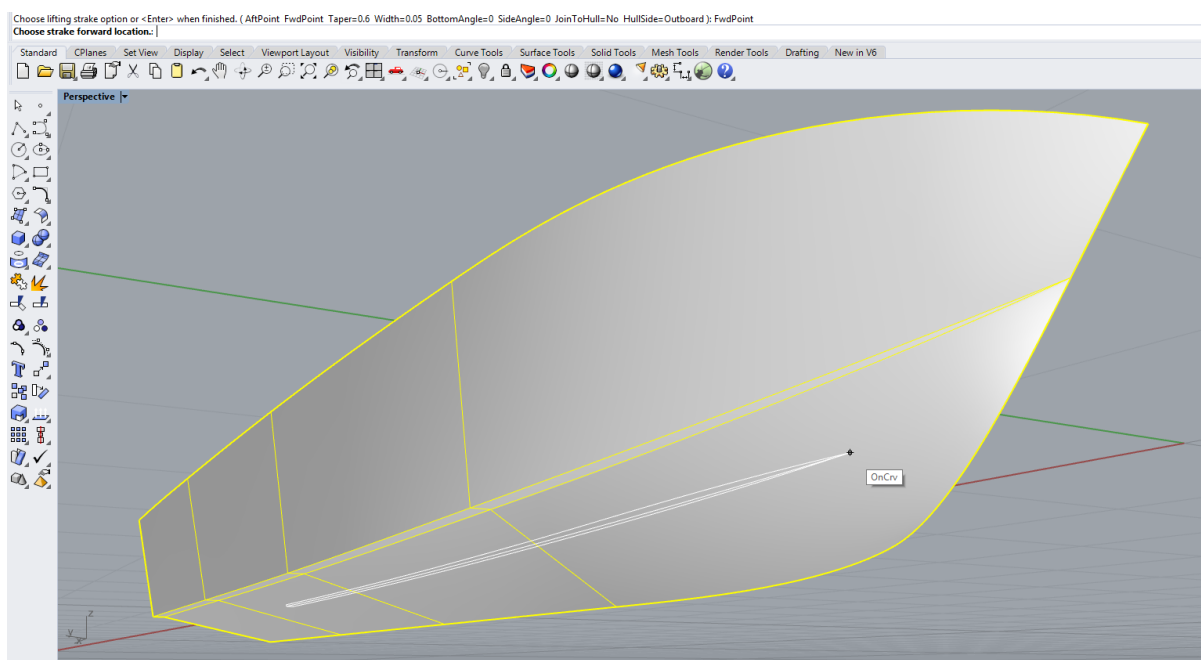
Command: OrcaCreateStrake

This command automates the process of creating a lifting strake or spray rail for a planing hull design. Once the command is started, the user selects the surface (or face in a brep) on which to create the strake. After selecting the surface, the user is queried to select the surface curve that will serve as the base curve for the strake. There are 3 options available as shown below, an iso-parametric curve, a section curve defined by intersecting the surface with an orthogonal plane, or a user-defined curve.

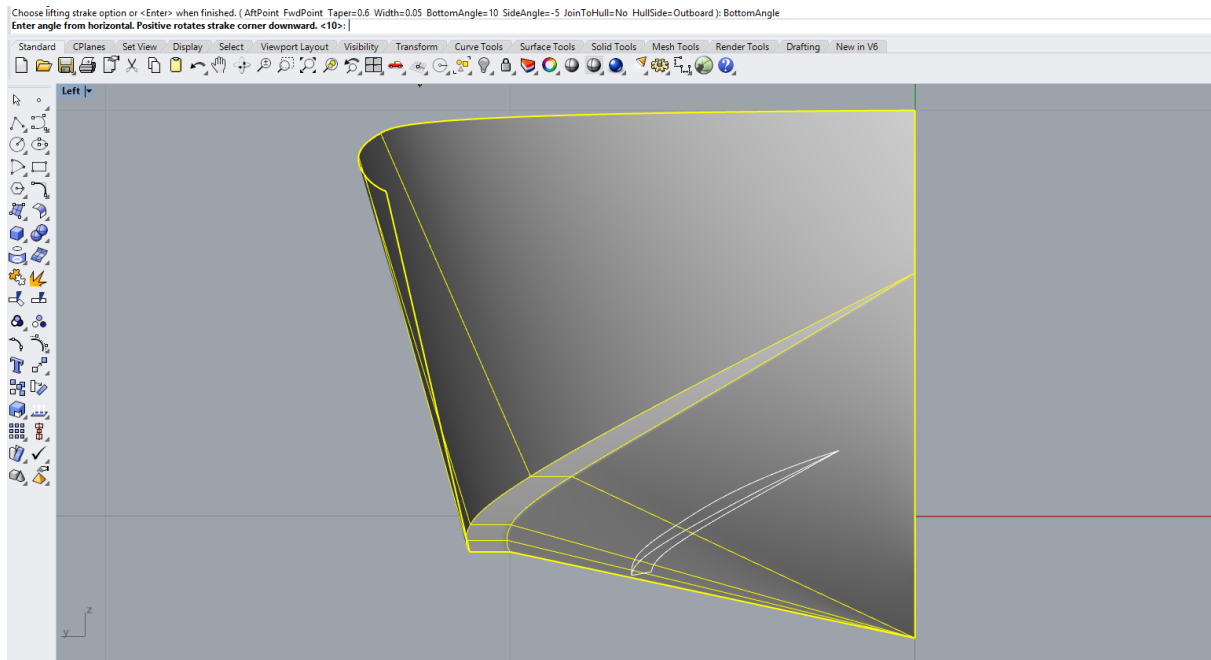


Once the strake base curve has been selected, the strake geometry is dynamically constructed and displayed. The user has several options for modifying the default geometry before creating the strake.

The “AftPoint” and “FwdPoint” options allow the user to limit the extent of the strake which by default extends to the end of the surface (or face if it is a trimmed surface) as shown below.

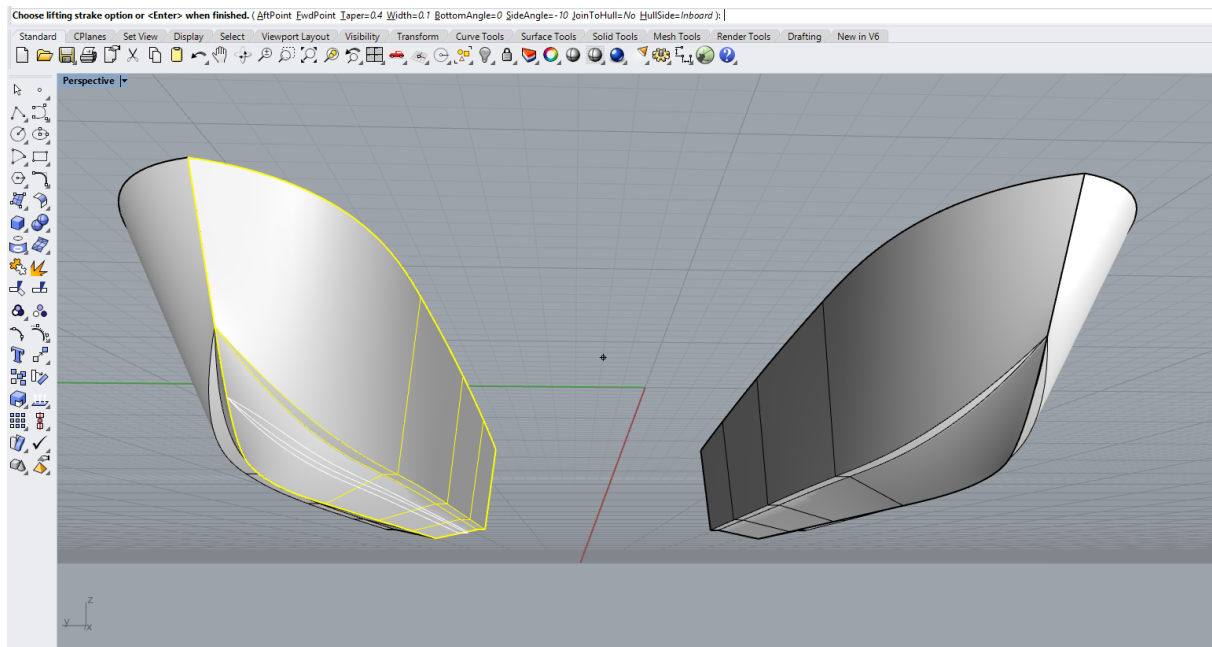


The “Width” controls the width of the strake bottom at its aft end. This option along with the “BottomAngle” and “SideAngle” options allow the user to modify the strake cross section shape as shown below.

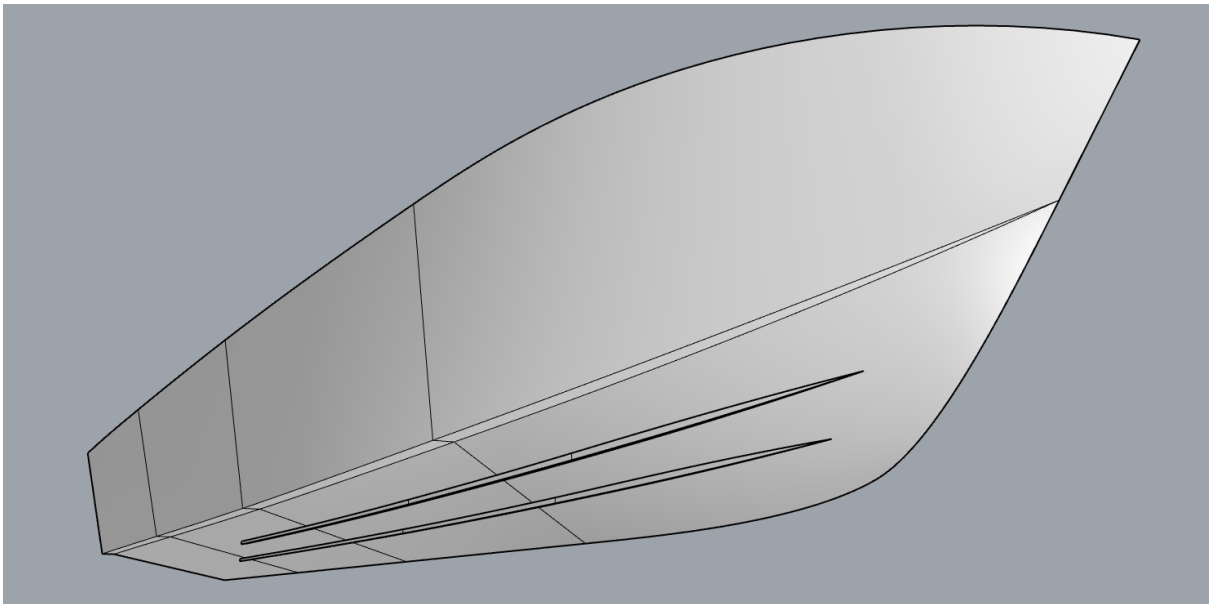


The “Taper” option defines the non-dimensional location along the strake length at which the cross-section geometry begins to taper to a point. The larger this value the further forward before taper starts.

The “HullSide” option allows the user to control whether the strake is being created on the Outboard or Inboard side of the geometry. The default is Outboard which is the logical default for a mono-hull. Orca3D is able to determine if you are creating the lifting strake on the starboard or port side of the hull and adjusts the strake geometry accordingly. However, sometimes you need to flip this option such as when you are creating a lifting strake on the inside hull surface of a catamaran. By changing the option to Inboard the strake will be properly created in this case as shown below.



Finally, the “JoinToHull” option is provided to automatically trim the face against the strake and join the strake and face into a single brep. An image below shows multiple strakes created and joined to the hull.

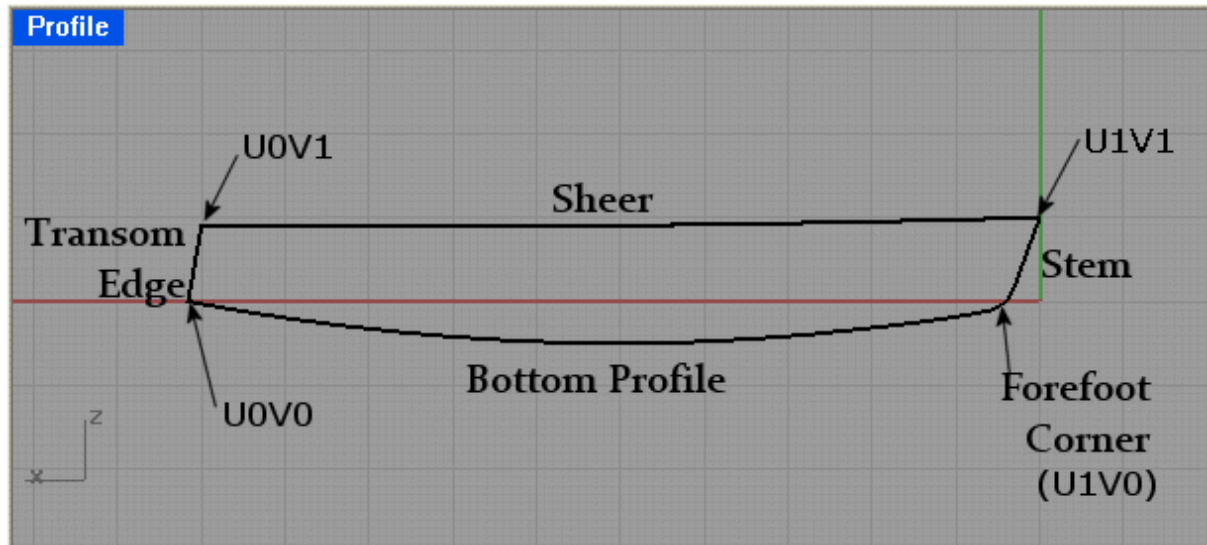


8.12 Corner Wrap

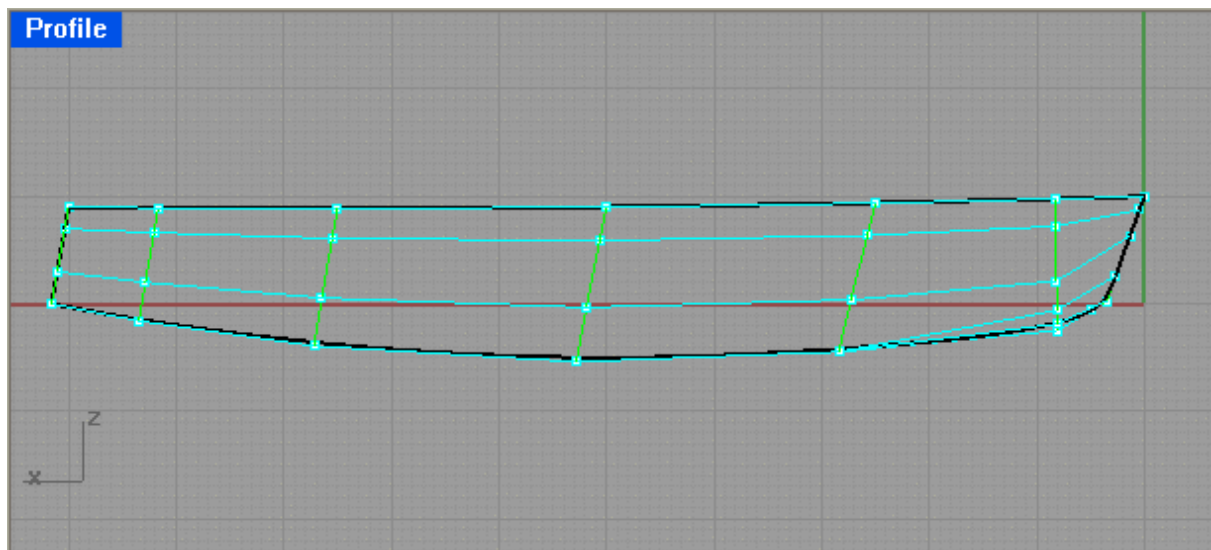
Toolbar	<i>n/a</i>
Menu	Orca3D > Hull Design > Corner Wrap
Command	OrcaWrapCorner

One of the characteristics of tensor product NURBS surfaces is that they fundamentally have four *corners* and four *edges*. As they are applied to hull design, the four *edges* usually correspond to the sheer line, the stem, the bottom profile, and the transom edge. The four *corners* are the intersections of these four *edges*. Generally, the *corners* represent geometric discontinuities in the surface, with the exception of the stem-bottom profile *corner* (forefoot). Here, it's usually the case that a smooth transition is desired, with at least slope continuity, but preferably with curvature continuity (which requires a surface that is cubic in both the U and V directions).

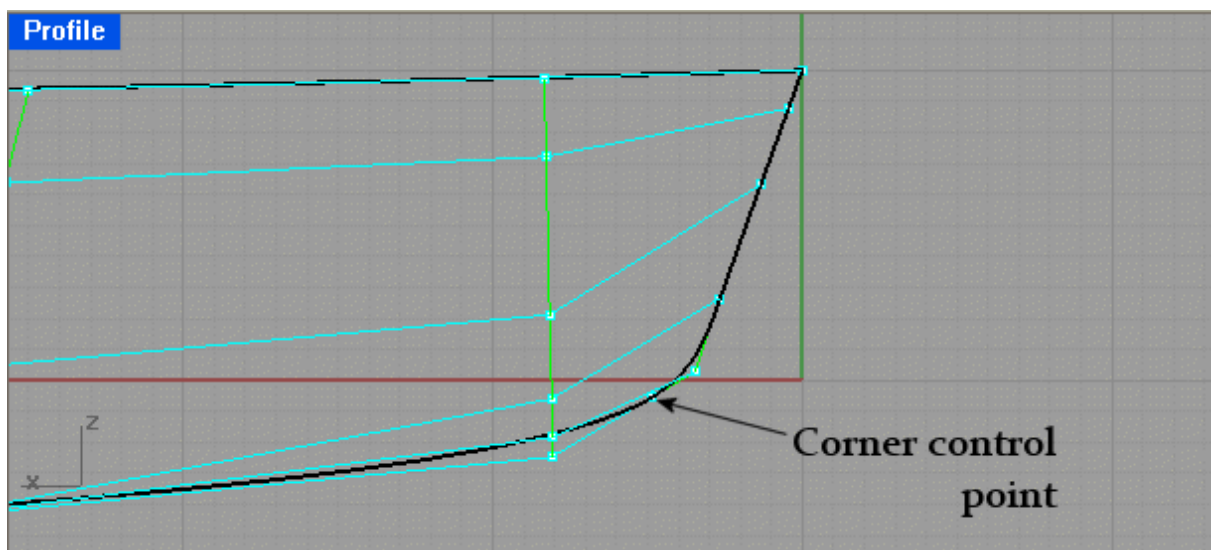
➔ Note: The Corner Wrap command requires that the surface have the same degree in both directions in order to guarantee curvature continuity.



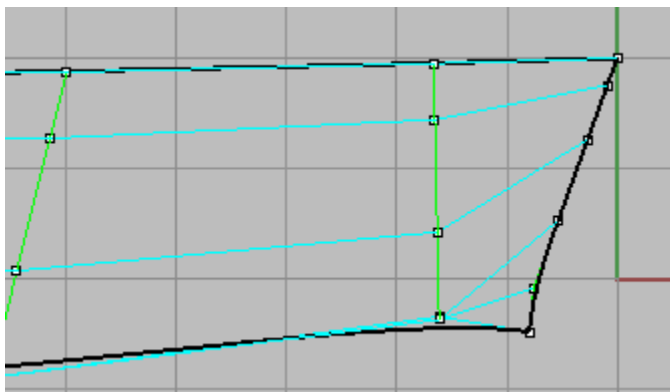
Orca3D provides a function to precisely place the corner control point to smoothly wrap one edge to another, with slope and curvature (if the surface is cubic or higher degree) continuity. The next figure shows an Orca control polygon:



A closer look at the forefoot shows the control point that is the corner of the surface:



To demonstrate the function, the corner control point has been moved, deliberately creating a discontinuity in the joint between the stem and the bottom profile:



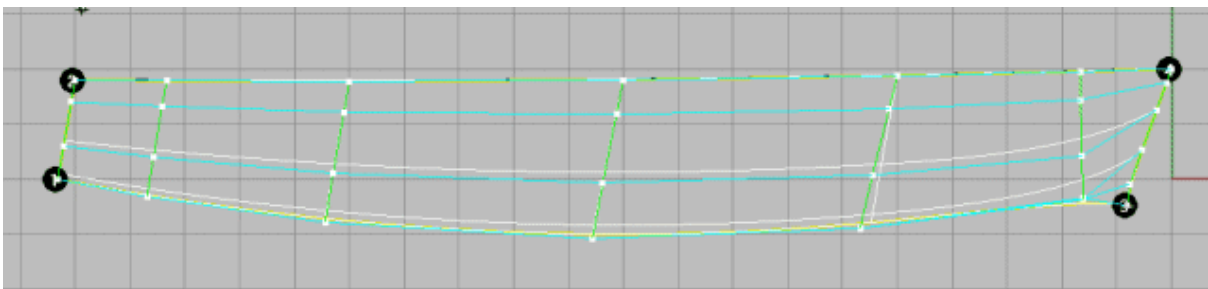
To re-create the smooth transition, select the **Corner Wrap** command from the **Orca3D > Hull Design** menu (note that it is not necessary to have the Orca control points turned on, but it is instructive to see how the corner point is moved to create the corner wrap). The first prompt asks which surface the corner wrap should be applied to, and the second prompt allows you to select which of the four corners should be smoothly wrapped:

Select surface for applying corner wrap.:

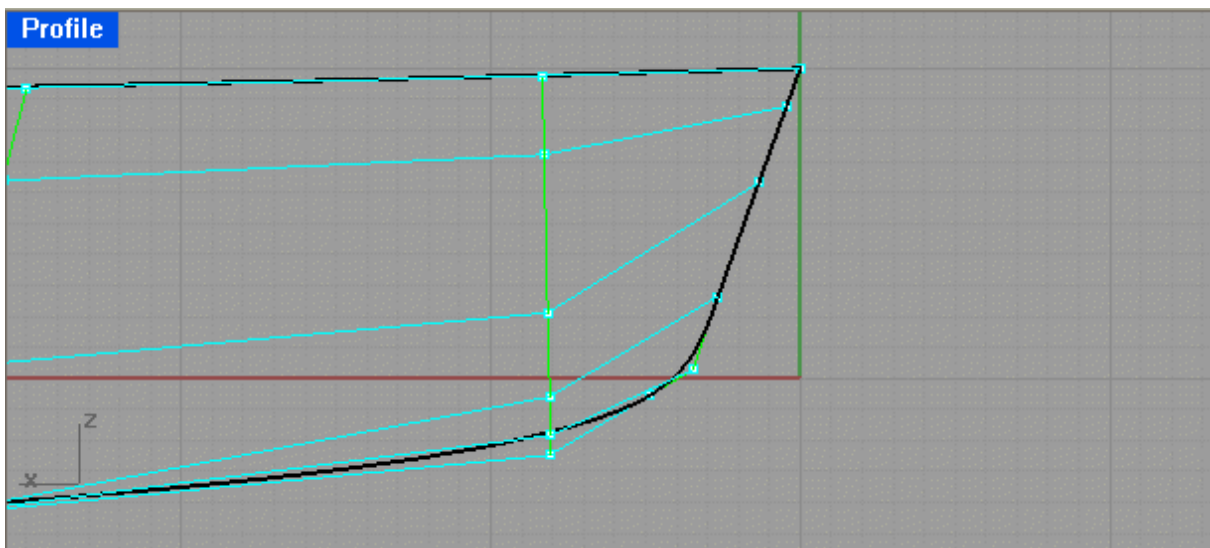
Select the corners to wrap (1st=Don't_Apply 2nd=Don't_Apply 3rd=Don't_Apply 4th=Don't_Apply EnableControlPoints):

(Note: Corner 1 will be MinUMinV; Corner 2 will be MinUMaxV; Corner 3 will be MaxUMinV; and Corner 4 will be MaxUMaxV. Your surface may vary from the figure below, depending on how it was created.)

Labels will be drawn on each of the four corners of the surface, numbered 1 through 4:



By clicking on the label on any corner of the surface, its corresponding Corner in the command line will toggle between "Apply" and "Don't Apply," and a preview of the wrapped shape will be shown. Once you have selected the desired corner(s), hit Enter to complete the command. The corner control point will now be precisely located to create continuity at that corner.



If your surface is cubic (degree 3) in both directions, the corner will have curvature continuity. If it is quadratic (degree 2), it will have slope continuity.

Finally, remember that the Corner Wrap function is an *action*, not a *property*. This means that it will move the corner point to create the corner wrap. If you move the corner point or


any of the two points (in the case of cubic surfaces) or one point (in the case of quadratic surfaces) along either edge away from the corner, your surface will no longer have the same continuity at that corner. You will need to run the Corner Wrap function again to re-create the continuity condition.

8.13 Lines Drawings

A lines drawing is a way for you to communicate your three dimensional model created in Orca3D into a two dimensional format for others to view.

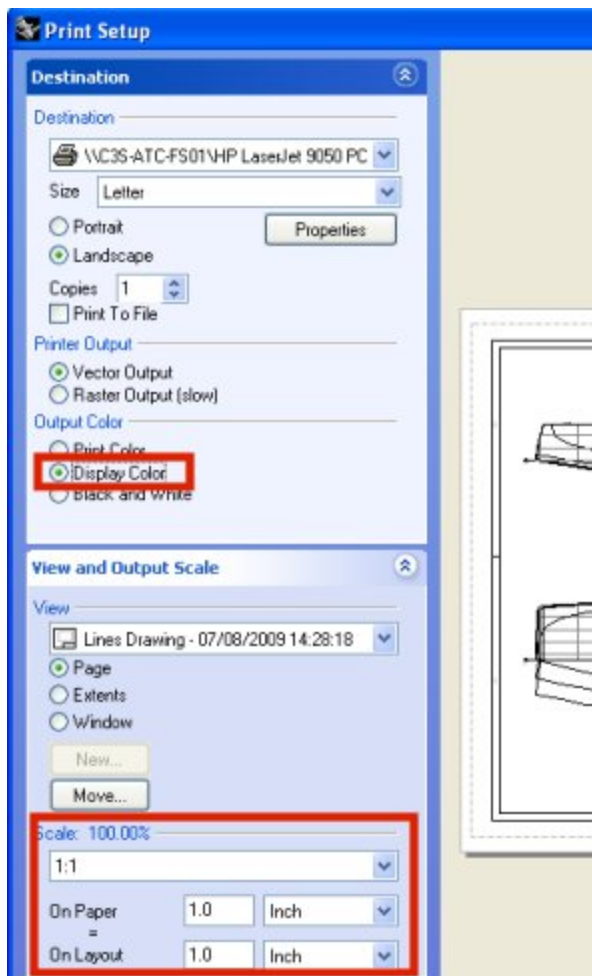
The Orca3D Lines Drawing command creates a new Page View within your Rhino file. The Page View contains 3 views of your model, one containing stations, one containing buttocks, and one containing waterlines and diagonals. (For more information on Layout views in Rhino, see Rhino's documentation on the **Layout** command.)

Orca3D's Lines Drawing command contains options to add section labels, a border, a title block, and principal characteristics. These objects are all added into separate layers so you can turn their visibility on and off with ease.

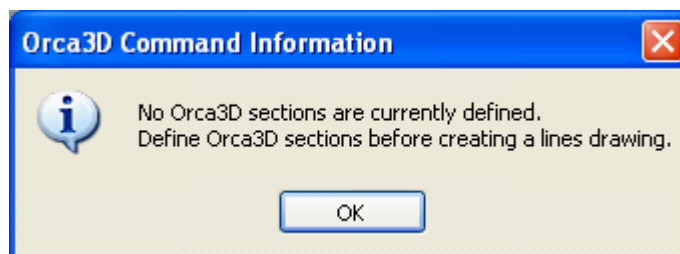
Toolbar	
Menu	Orca3D > Hull Design > Lines Drawing
Command	OrcaCreateLinesDrawing

Notes:

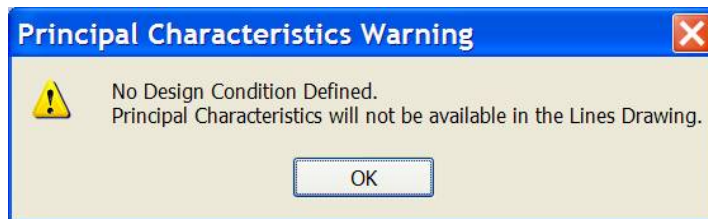
- Make sure that you have created sections of your model using the OrcaSections command.
- If you wish principal characteristics to be included, make sure that you have defined a [Design Condition](#)^[132] in the Stability section of Orca3D.
- If you wish station annotations to contain station locations instead of station numbers, simply enter the most forward point of your hull for the Station 0 location, and type 1 as the station spacing.
- When printing, if you wish your lines drawing to be printed correctly on the indicated paper size, in the Rhino Print Setup dialog make sure to select the printing scale as 1:1, and set the output color to display colors.



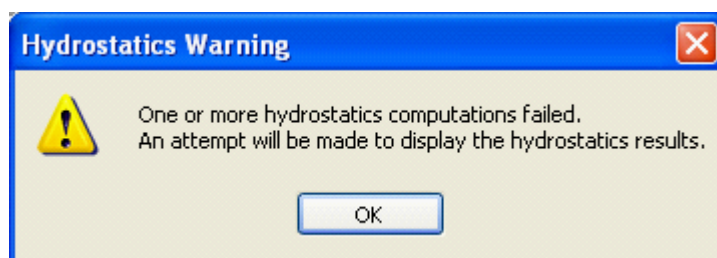
1. Start the command with the toolbar icon, menu selection or keyboard command.
 - a. If the following dialog box appears, then you have not created sections using OrcaSections. Please [create sections](#)^[237] before using the OrcaCreateLinesDrawing command.



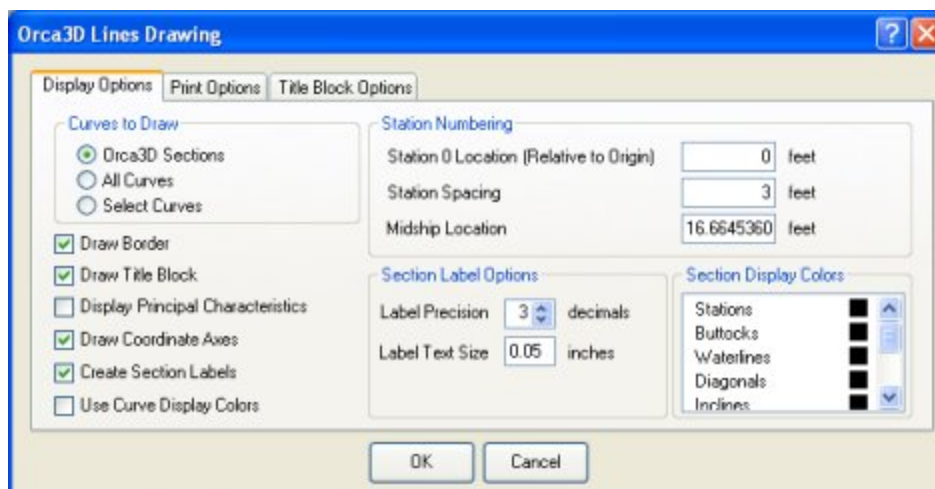
- b. If this dialog box appears, then you have not defined a Design Condition. You may still continue to create the lines drawing, but if you wish to include principal characteristics in your drawing, you must first [define the Design Condition](#)^[132].



- c. If this dialog box appears, then there was an error computing your Design Condition. You may still continue to create the lines drawing, but if you wish to include principal characteristics in your drawing, you must first [define the Design Condition](#)¹³² correctly.



2. The Orca3D Lines Drawing dialog box will appear, with the **Display Options** tab selected:



3. Select which curves to include; only Orca3D Sections, All Curves in the drawing, or you may select the specific curves to include

4. Check any of the next six check boxes depending on what you wish to be visible on the lines drawing.
 - a. In order to display Principal Characteristics, you must have defined a [Design Condition](#)¹³² before starting the Lines Drawing function

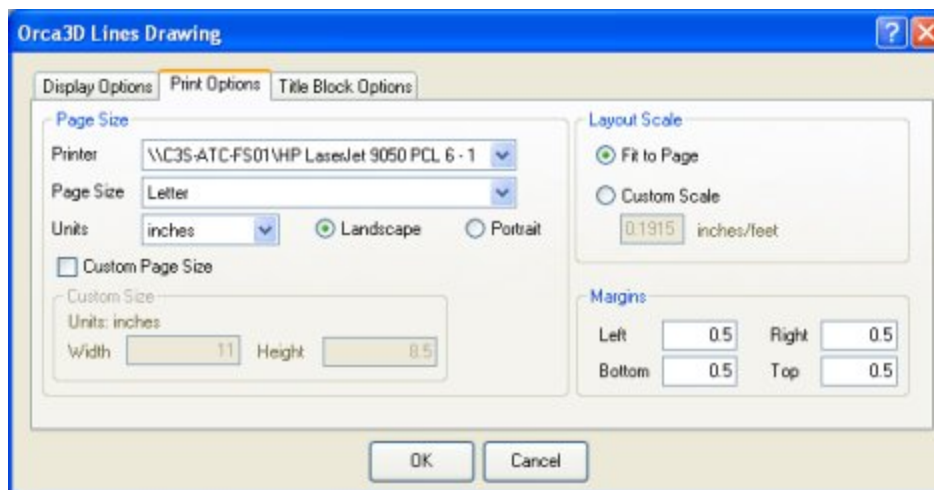
Station Numbering

5. Type the location of Station 0 relative to the origin. This uses the units that your model is in, not the page units.
6. Type the station spacing in the model units. The stations will be labeled with station numbers according to these values.

Section Label Options and Display Colors

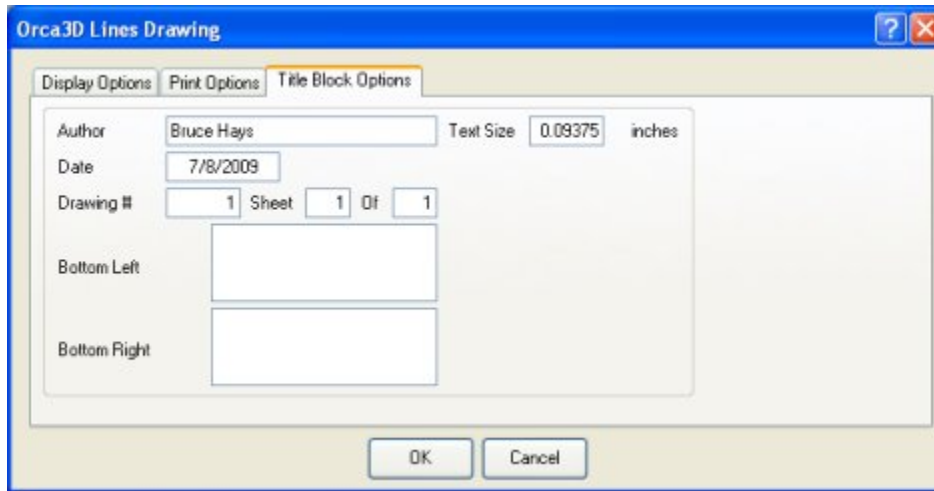
7. Enter the Label Precision and Label Text Size
8. Select a color for each of the Section types (by default they are all black, so that they will show up well on a black and white printer)

The **Print Options** tab is shown below:

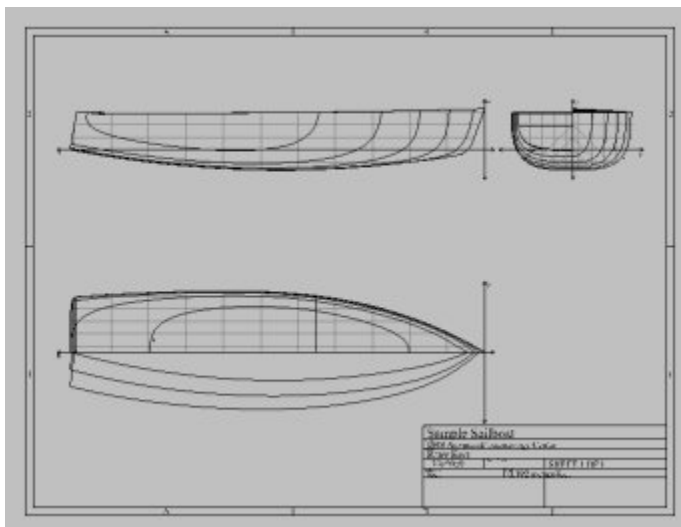


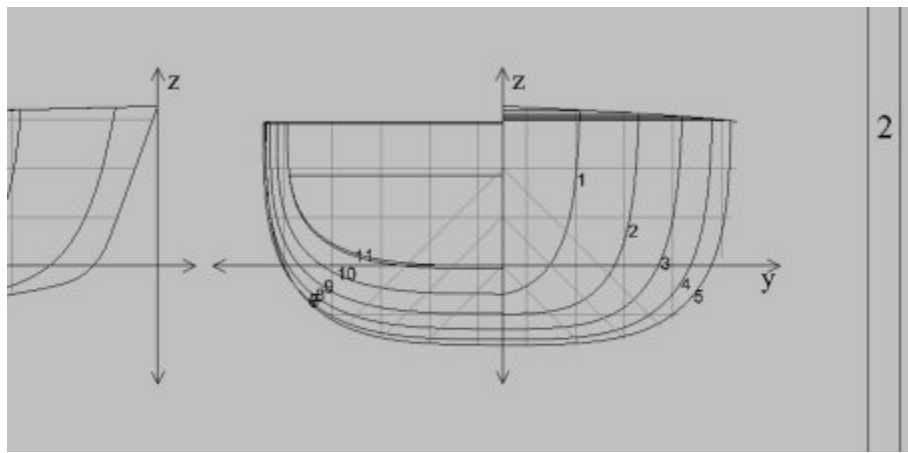
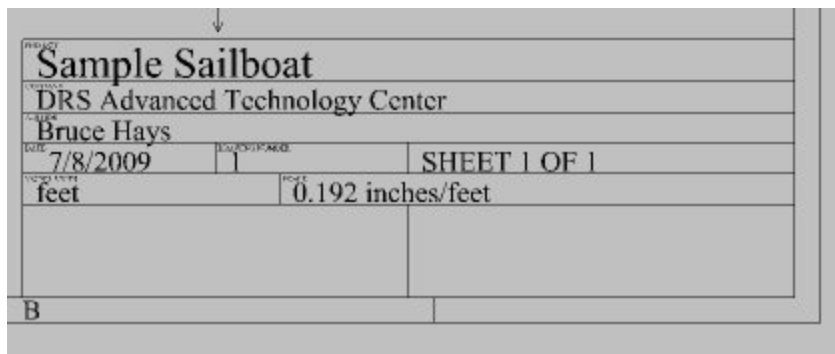
9. Select the printer that has the paper size you wish to use.
10. Select the Page size that you wish your lines drawing to be created on.
11. Select the units for the page size.
12. Select whether you wish the page to be in landscape or portrait format.
13. If you wish to enter a custom page size, select the checkbox.
 - a. If selected, enter your custom page size in the lower left; this is in the units selected previously.
14. Edit the paper margins. They are in the units you selected above.
15. Select either Fit to Page, or Custom Scale. Fit to Page will fit the three views of your model as best it can onto the paper size you have selected, whereas Custom Scale uses a scale of your choice.
 - a. If you chose Custom Scale, enter the scale you wish to use in decimal format.

The **Title Block Options** tab is shown below:

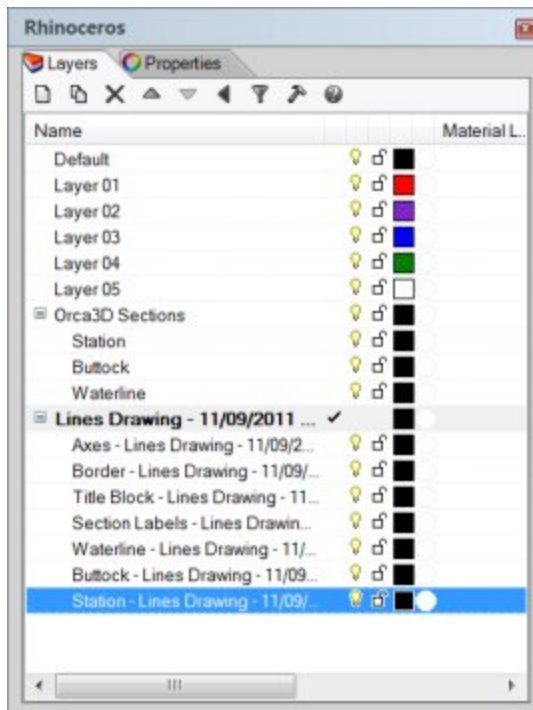


16. If you selected "Display Title Block" in the Display Options tab, you can edit the specifics of the title block here.
 - a. Fill in all of the named items with the appropriate information.
 - b. The bottom left and bottom right items are to be used at your discretion. They can be filled with whatever information you want within your title block.
 - c. Enter a size for the Title Block text.
17. Select OK
18. Your lines drawing is created using the information you provided. Notice that the diagonals are shown in their own planes, below the planview. The appropriate information has been included in the title block, as shown in the second figure below. The third figure shows a close up of the bodyplan, where you can see the section labels.





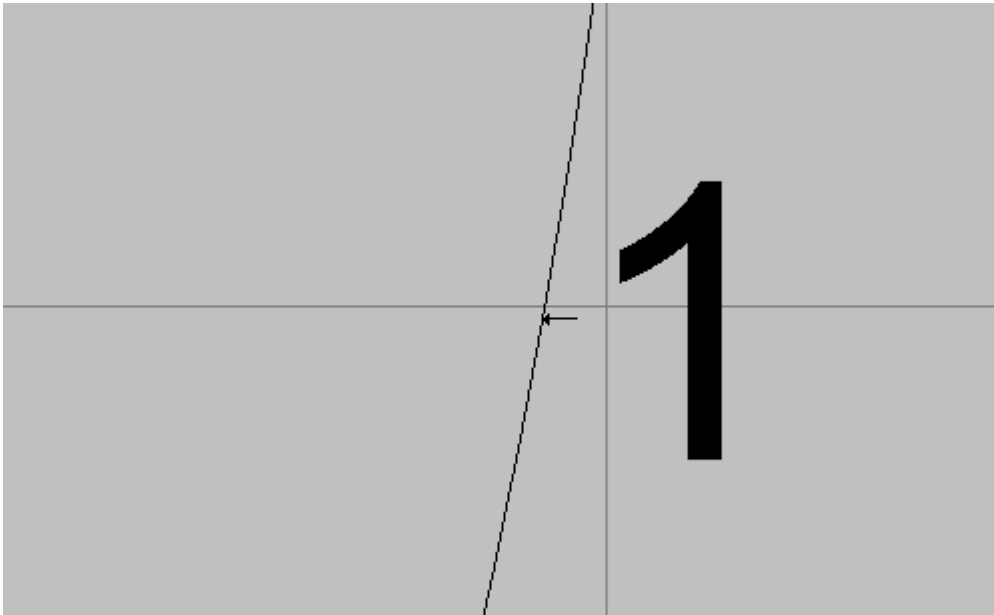
You will notice the objects are placed in separate layers, as shown below:




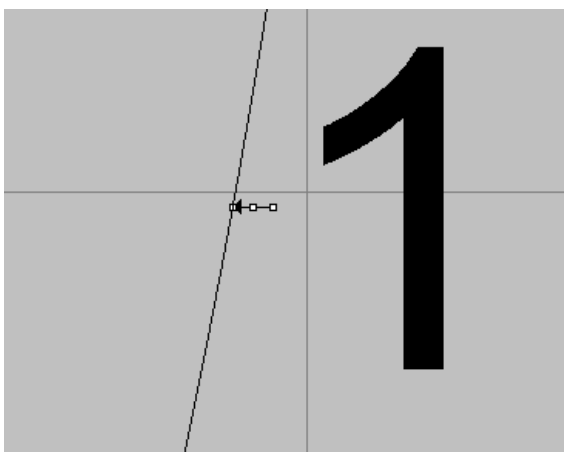
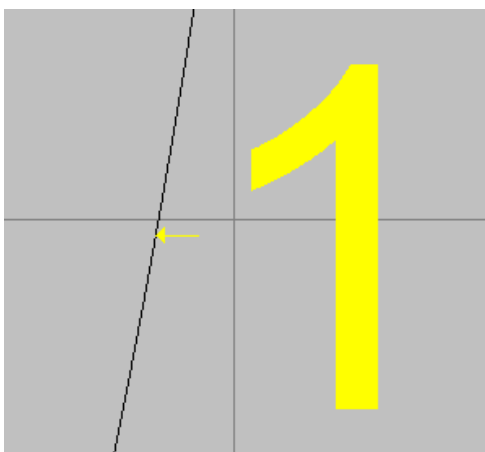
You may turn off visibility, lock, or delete the layers as you wish to better manage your lines drawing.

The Layout and the Layer will be labeled with the time and date that the Lines Drawing was created. The drawing will be up to date with the model as of that time. Any further changes to the model *are not* reflected automatically in the Lines Drawing. You will need to create a new Lines Drawing if you modify your model.

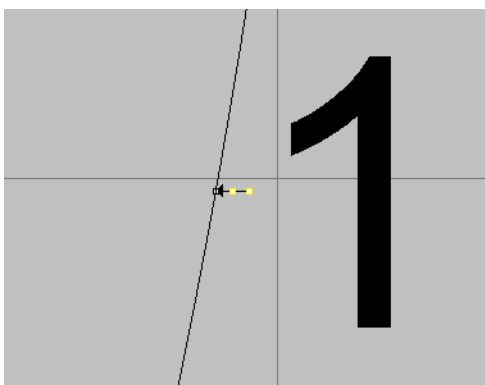
In case the section labels overlap or you wish them to be in a different location, they can be easily moved. First select the section label you wish to move and zoom all the way in as follows:

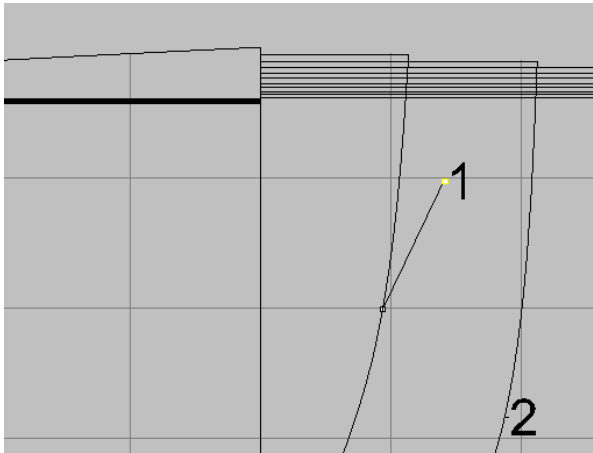



Then turn the Rhino control points on by selecting the section label and either navigating the menu to (Edit > Control Points > Control Points On) , typing PointsOn in the command line, or left-clicking the  icon.



Next, select the right two control points, and move them wherever you wish the section label to be moved to.






To Finish, deselect the control points and turn them off by navigating the menu to (Edit > Control Points > Control Points Off), typing PointsOff in the command line, or right-clicking the  icon.

If you would like to place a Table of Offsets on the Lines Drawing, the easiest way is to capture an image of the Offset Table and save it as a jpeg file. Then, use Rhino's *BackgroundBitmap* function to place the jpeg image on the drawing.

8.14 Offset Tables

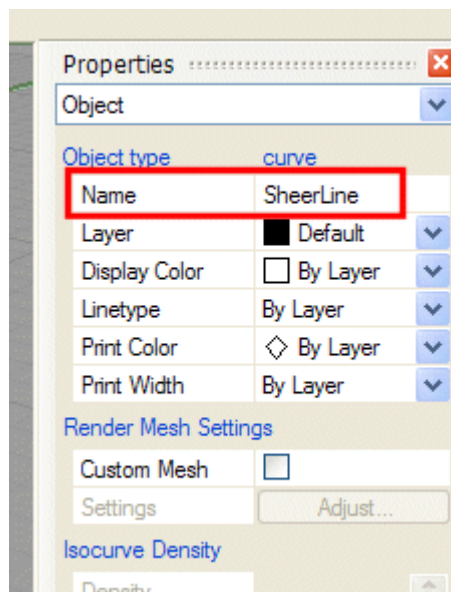
Although most vessels are built with numeric methods, sometimes a traditional table of offset is still required. Orca3D can produce a table in Excel showing buttock heights, waterline half-breadths, and 3D curve (sheer, chine, etc.) intersections with tables.

Toolbar	 (right-click)
Menu	Orca3D > Hull Design > Offset Table
Command	OrcaOffsetTable

Note: You must have *Excel* installed for this function to work.

The first step to creating a table of offsets is to create the curves that will be included. These can be created with the Orca Sections command, or any other curve creation routines in Rhino. In particular, you may wish to define curves for:

- the sheerline by using Rhino's DupEdge command (in the menu, select Curve > Curve from Objects > Duplicate Edge). You should give the curve a name, using Rhino's Properties command, as in this example:



- If your hull has chines that are surface edges, follow the same procedure. If the chines are in the interior of the surface, use Rhino's ExtractIsoCurve command (in the menu, select Curve > Curve from Objects > Extract Isocurve) to create a curve that matches your chines.

Start the OrcaOffsetTable command from the command line, the menu, or by right-clicking on the icon. You will immediately see the prompt with the command options in the command line:

Choose option or <Enter> (FeetInchesEighths=Off UseOrcaCurves=On):

- **FeetInchesEighths:** Normally the data in the offset table is shown in the units of your Rhino model. If you change this option to On, the Waterline Half-Breadths and Buttock Heights will be shown in the format Feet-Inches-Eighths+/- . Note that the Station location values will still be shown in your Rhino model units.
- **UseOrcaCurves:** With this option turned On, the stations, buttocks, and waterlines that you have defined in the OrcaSections dialog will be used in the offset table. If you change this to "Off" you will be prompted to select the sections to be included.

The program must be able to find at least one station, at least one buttock, and at least one waterline.

Hit Enter. A message will appear above the command prompt with the number of curves of each type that have been found:

An instance of Excel will be opened, and the data filled in the worksheets:

A1 WATERLINE HALF-BREADTHS								
Name Box	B	C	D	E	F	G	H	
1	WATERLINE HALF-BREADTHS							
2	Waterline	Waterline	Waterline	Waterline	Waterline			
3	Station	-0.250	0.000	0.250	0.500	0.750	SheerLine	Station
4	0.500		0.050	0.164	0.230	0.262	0.280	0.500
5	1.500	0.168	0.575	0.668	0.706	0.724	0.733	1.500
6	2.500	0.701	0.910	0.993	1.033	1.053	1.062	2.500
7	3.500	0.963	1.148	1.226	1.263	1.280	1.286	3.500
8	4.500	1.124	1.300	1.374	1.407	1.419	1.423	4.500
9	5.500	1.190	1.373	1.447	1.477	1.486	1.487	5.500
10	6.500	1.168	1.378	1.461	1.492	1.499	1.499	6.500
11	7.500	1.047	1.336	1.437	1.473	1.480	1.480	7.500
12	8.500	0.591	1.241	1.387	1.437	1.446	1.445	8.500
13	9.500		1.027	1.300	1.377	1.391	1.389	9.500

If multiple intersections are found on a single station, there will be two rows for that station. If there is more than one curve that describes a particular station, there will be two entries in the offset table. If possible, you should join all of the curves that are at a single station location.

A1 BUTTOCK HEIGHTS								
	A	B	C	D	E	F	G	H
1	BUTTOCK HEIGHTS							
2	Buttock	Buttock	Buttock	Buttock	Buttock			
3	Station	0.250	0.500	0.750	1.000	1.250	SheerLine	Station
4	0.500	0.636					0.986	0.500
5		0.986						
6	1.500	-0.238	-0.103				0.962	1.500
7		0.962	0.962					
8	2.500	-0.370	-0.337	-0.211	0.281		0.941	2.500
9		0.941	0.941	0.941	0.941			
10	3.500	-0.451	-0.434	-0.376	-0.215	0.393	0.924	3.500
11		0.924	0.924	0.924	0.924	0.924		
12	4.500	-0.494	-0.481	-0.443	-0.345	-0.094	0.910	4.500
13		0.910	0.910	0.910	0.910	0.910		
14	5.500	-0.494	-0.484	-0.452	-0.376	-0.190	0.900	5.500
15		0.900	0.900	0.900	0.900	0.900		
16	6.500	-0.454	-0.445	-0.416	-0.345	-0.178	0.894	6.500
17		0.894	0.894	0.894	0.894	0.894		
18	7.500	-0.378	-0.369	-0.340	-0.271	-0.106	0.891	7.500
19		0.891	0.891	0.891	0.891	0.891		
20	8.500	-0.267	-0.258	-0.228	-0.160	0.009	0.892	8.500
21		0.892	0.892	0.892	0.892	0.892		
22	9.500	-0.119	-0.109	-0.081	-0.012	0.172	0.896	9.500
23		0.896	0.896	0.896	0.896	0.896		
24	10.000	-0.030	-0.021	0.007	0.078	0.280	0.900	10.000
25		0.900	0.900	0.900	0.900	0.900	0.900	

8.15 Exporting Curves

Toolbar	<i>n/a</i>
Menu	Orca3D > Hull Design > Export Curves
Command	OrcaExportCurves

Orca3D can export Section curves to these formats:

IDF: IMSA Definition Format--The IDF specification allows for a number of different types of entities (sections, points, surfaces, meshes, etc.). This interface exports only sections as polylines. See [below](#) ^[229] for the IDF specification for Sections.

PIAS: This interface exports only stations in a format suitable for use in the SARC Pias software. It is a very simple format that may be of use in other programs as well:

- Number of Stations
- Longitudinal Location of the Station
- Number of points in the Station
- Half Breadth, Height, Breakpoint Indicator
- Next curve...

The [model orientation](#) ^[80] is used to write the curves from stern to bow and from keel to deck.

ORC: This format is compatible with the Offshore Racing Congress requirements (see www.orc.org).

To export in one of these formats, select the curves to be exported, and then select Export Curves from the **Orca3D > Hull Design** menu. In the Export Filename dialog, select the file type, enter a file name, and click on Save. A dialog will be shown that allows for controlling the smoothness of the curves:

IDF Export Options

IDF Partname:

Curve Tessellation Parameters

Maximum Angle:

Chord Height:

Maximum Aspect Ratio:

Tolerance:

Segment Count:

Minimum Segment Length:

Maximum Segment Length:

☐ Join Curves

OK Cancel

PIAS Export Options

Curve Tessellation Parameters

Maximum Angle:

Chord Height:

Maximum Aspect Ratio:

Tolerance:

Segment Count:

Minimum Segment Length:

Maximum Segment Length:

☐ Join Curves

OK Cancel

ORC Export Options

Curve Tessellation Parameters

Maximum Angle:

Chord Height:

Maximum Aspect Ratio:

Tolerance:

Segment Count:

Subsegment Count:

Minimum Segment Length:

Maximum Segment Length:

☐ Join Curves

Output Units

☒ Millimeters ☐ Feet (x 100)

Fwd/Aft Freeboard Location

- ☐ X = 0.1
- ☐ X = 0.507934714131879
- ☐ X = 1.01586942826376
- ☐ X = 1.52380414239564
- ☐ X = 2.03173885652752
- ☐ X = 2.5396735706594
- ☐ X = 3.04760828479128
- ☐ X = 3.55554299892316
- ☐ X = 4.06347771305504
- ☐ X = 4.57141242718692
- ☐ X = 5.0793471413188
- ☐ X = 5.58728185545068
- ☐ X = 6.09521656958256
- ☐ X = 6.60315128371444
- ☐ X = 7.11108599784632
- ☐ X = 7.6190207119782
- ☐ X = 8.12695542611008
- ☐ X = 8.63489014024196
- ☐ X = 9.14282485437384
- ☐ X = 9.65075956850572
- ☐ X = 10

OK Cancel

For ORC files, you must also select the two stations that correspond to the Forward and Aft Freeboard locations (only select two). The Join Curves checkbox will join curves across multiple surfaces (e.g., a hull and keel).

The Curve Tessellation Parameter values on these dialogs are defined as follows:

Maximum Angle	Maximum angle (in radians) between unit tangents at adjacent vertices.
Chord Height	Maximum permitted value of (distance chord midpoint to curve) / (length of chord)
Maximum Aspect Ratio	If < 1.0 , the parameter is ignored. If $1 \leq \text{Maximum Aspect Ratio} < \sqrt{2}$, it is treated as if Maximum Aspect Ratio = $\sqrt{2}$. This parameter controls the maximum permitted value of (length of longest chord) / (length of shortest chord)
Tolerance	If Tolerance = 0, the parameter is ignored. This parameter controls the maximum permitted value of the distance from the curve to the polyline.
Segment Count	If non-zero, the curve will be broken into this number of equally spaced chords
Minimum Segment Length	This parameter controls the minimum permitted edge length.
Maximum Segment Length	This parameter controls the maximum permitted edge length.

INTERFACE DEFINITION FILE (.IDF)

The IMSA IDF is intended to be a neutral file format for exchange of hull description data between marine programs, without the generality or complexity of standards such as IGES and DXF, and without the specific traits of a particular program's native format.

The file is designed to be easily human-readable. Compactness is sometimes sacrificed for this goal.

GENERAL FORM

\$IDF**3.03****\$ENTITY**

entity type

\$VESSEL NAME

identifier for this vessel

\$DATA SOURCE

name of program that wrote the file

\$DATE

date

\$TIME

time

\$UNITS

units

\$COORDINATE SYSTEM

coordinates of a point one unit forward,starboard,down ("coordinate gnomon")

e.g. for FAST YACHT 1,1,1

\$COMMENTS

comments

comments

\$GEOMETRY

(data format specific to geometry type from here down)

\$END ENTITY

Current Entity Types (only the Sections entity is currently supported by Orca3D, and the following specification is only for this entity type):

Entity Type	Description
SECTIONS	Sectional Data (Stations, Buttocks, Wls, 3d curves)
MESH	Surface Mesh data
NURBS	NURBS Surface data
HYDRO	Hull Parameter data
AREA	Sectional Area Data

General Comments

This standard contains only one interface file. This file can contain one or more entities, where each entity is a specific data type (e.g. hull sectional data, NURBS surface data, etc.). This avoids having many different files, and allows new entities to be added as necessary. It also means that one file can contain different types of data for a single ship (sectional data, surface data, etc.), thus avoiding many files describing the same ship.

The file will be a simple ASCII file, so that it will be transportable across different hardware platforms, as well as being easily human-readable. While this does not result in the most compact format, it does result in a format that is easy to produce, read, add to, and modify.

Data for each line item are to be separated by commas. Comments may be added on any line following an exclamation mark (!). End of line sequence is to be appropriate to the operating system. Text strings may be up to 79 characters long, and are limited to ASCII characters 1 through 127.

Units

Units must be specified as either: **SI** or **User Defined**. If **User Defined**, then the following lines must be given:

of user units/meter

of user units/square meter

of user units/cubic meter

of user units/kg

Some entities may not require all of the conversion factors, and the entity's definition will specify which should be included.

Coordinate System

Since different programs use different coordinate systems (e.g. some have positive X aft,

some have positive X forward, some use Z for the longitudinal coordinate, etc.), the coordinates of a fixed point in space is required. This point is one unit forward of the origin, one unit to starboard, and one unit down from the origin. Then, as data is read in from the file, by multiplying the data by the given vector and by your own vector, the sign will be correct. All data in the formats is given in the order longitudinal, athwartships, and height. Not all entities will have a coordinate system associated with them. If not, the entity definition will leave this section out.

Data Tags

Data tags (e.g. \$ENTITY), while not absolutely required in a fixed format file, make the file easily human-readable, and can simplify the computer-reading process. Import programs that are searching for a particular ENTITY type, can search the file for the string "\$ENTITY", and then read the next line to see if the type is correct, and go on from there.

Data tags (items preceded with \$) must have the \$ in column 1, i.e. no white space is allowed before a data tag. Leading white space (tabs, spaces) is allowed on lines containing data. Blank lines are allowed between data and the next data tag.

Any data that is shown in the entity definitions is required; if not known, dummy data should be substituted.

Where entities allow for more than one body or surface, it is subdivided into parts (each part may represent a body or surface, or a group of bodies).

Entity #1: Sectional Data (SECTIONS)

Note: Indenting is for clarity only; not used in actual data file.

\$IDF

3.01

\$ENTITY

SECTIONS

\$VESSEL NAME

Identifier for this vessel

\$DATA SOURCE

program that wrote the file

\$DATE

mm/dd/yy

\$TIME

hh:mm:ss

\$UNITS

This line must be either **SI** or **User Defined**

If **User Defined**, then the following line(s) must be specified:

of user units/meter

\$COORDINATE SYSTEM

coordinates of a point one unit forward,starboard,down ("coordinate gnomon")

e.g. for FAST YACHT 1,1,1

\$COMMENTS

This is a comment about the ship about to be described. Can be any # of 79 character lines.

\$GEOMETRY

n (number of parts or bodies)

part 1

.

.

part n

where each part format is:

\$PART

part name

m (number of curves)

curve 1

.

.

curve m

where each curve format is:

\$CURVE

curve name

Curve type (station, buttock, waterline, cant, incline, diagonal) diagonal, general plane, three-D)

j=integer number of points on curve

point 1

.

.

point j

where points are coordinate triplets (long'l, trans ,vert), breakpoint indicator (unknown, fair, knuckle)

for example: 10.15, 3.25, 1.50, fair

\$END ENTITY

Part

IX

9 Sections

This section describes the most common basic tasks you will use when computing sections with Orca3D. It is designed as a "How-To" guide. You can use the table of contents as an index. Although it is organized roughly in the order that you would perform the tasks you don't need to begin at the beginning and work your way through. Every topic contains comprehensive links to background information and other relevant subjects so you can just pick out the task you need to perform and begin.

See also:

[Introduction](#) ⁷⁰

[Quick Start Tutorial](#) ⁹³

9.1 Introduction

Toolbar	
Menu	Orca3D > Hull Design > Sections
Command	OrcaSections

The term "Sections" refers to planar curves such as stations, buttocks, and waterlines, that are computed as the intersection of a plane with one or more surfaces. Orca3D uses Rhino's *contour* command to compute the curves. The Section curves are just like any other Rhino curves, except that they "know" that they were derived from a surface, and if you use Orca3D's [real-time section updating](#) ²⁴¹, they will update as the surface is modified. If you select a Section and look at its properties, next to Object Type it will display "Orca3D section."

Orca3D provides an interface to quickly define a list of station, buttock, waterline, diagonal, cant, and incline locations. This list is maintained and stored with your model, and sections will be computed at these locations through the surface(s) that you have selected.

When you define sections, they are associated with one or more surfaces. They will only be computed through the surfaces that you select when you begin the command. If you wish to have sections through a different set of surfaces, simply select those surfaces, run the *Orcasections* command again, and click OK.

Important Points to Remember

1. Because the Section curves will change if the surface is changed, you should copy any of them that you want to use for a different part of your drawing. **Note that you must use the Copy command that is in the Edit menu (same as CTRL-C) and the Paste command in the Edit menu, rather than the Copy command in the command line or the Transform menu. Otherwise, the copied curve will still be associated with the surface, and it will**

disappear when the surface is modified or deleted.

2. Because Sections are associated with a surface, they cannot be directly edited or deleted. They will only change shape if the underlying surface is modified, and the only method of deleting a Section curve is to remove it from the section list in the Sections dialog.

3. If you mirror a surface that has sections defined, but you do not select the Orca3D sections as objects to be mirrored, the mirrored surface will not have Orca3D sections. In order to see Orca3D Sections on the mirrored surface, you must select the mirrored surface along with the original surface, and update the Sections (right-click on the Sections icon).

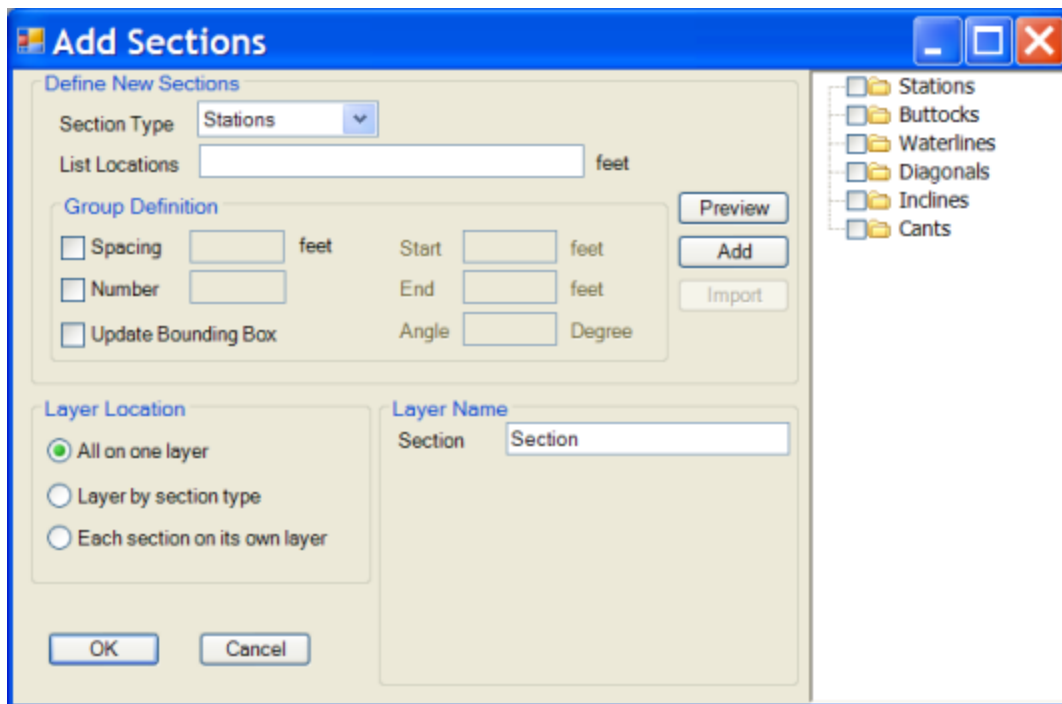
4. If you mirror Orca3D sections, either by themselves or along with their parent surface, the mirrored sections *will disappear if the original surface is modified*. If you wish to associate them with the mirrored surface, select all of the surfaces and update the Sections (right-click on the Sections icon).


9.2 Defining Section Locations

The first step to getting sections, of course, is to define their locations. Orca3D provides an interface to quickly define a list of station, buttock, waterline, diagonal, cant, and incline locations. This list is maintained and stored with your model, and sections will be computed through the surface(s) that you have selected, at these locations.

Toolbar	
Menu	Orca3D > Hull Design > Sections
Command	OrcaSections

1. Start the command with the toolbar icon, menu selection, or keyboard command.
2. Select the surface(s) to be included (or you may preselect the surfaces prior to starting the command)
3. The Add Sections dialog will appear:



4. Select the type of Section that you want to add to the list (Stations, Buttocks, Waterlines, Diagonals, Inclines, or Cants)
5. Define the Section locations by List (plane constant), and/or Spacing or Number. Checking "Update Bounding Box" will automatically fill in the minimum and maximum dimensions of the selected surface(s) in the direction perpendicular to the Section type in the Start and End fields. Note that if the Start value is less than the End value, the Spacing must be greater than 0, and if the Start is greater than the End, the Spacing must be less than 0. See [Defining Locations](#)^[239] below for more detail.
6. Select the Layer location for the Sections.
7. Click Add to add your Sections to the Sections list. The list of Section locations will be shown in the Section tree.
8. Click Preview to see planes in the model representing the Section locations.
9. Repeat for other Section types.
10. You may turn off visibility for one or more Sections, using the check boxes in the tree.
11. You may right click on any Section in the tree to remove it, preview it, or change its color.
12. Right-click on a node (for example, "Stations" to operate on all of the sections of that type.
13. Click on OK. The Sections will be computed on the selected surface(s). If this surface is edited using the Orca control points, they will be updated in real-time.
14. The calculation and visibility of all of the Sections may be temporarily turned off, using the **OrcaShowSection** command, or the icon (). Individual Sections or groups of

Sections may be turned off with the checkbox in the Sections tree. When turned off, the Sections will not be computed or displayed, and will not be included in analyses (such as the sectional area curve in Hydrostatics).

You may also define your section locations by importing the section list from another Rhino model. Click on the Import button, and navigate to the desired model. If the units of the imported section list are different from the current model, they are converted into the current model units. For example, if the station spacing in the imported model was one foot, and the current model is in meters, the station spacing would be 0.3048 meters. You must select the Layer Location for imported sections; that information is not imported from the other model.

Defining Locations

When you specify Section locations, you are specifying a plane constant. For example, if X is the longitudinal coordinate, Y is transverse, and Z is vertical, then:

- Stations are defined by an X value
- Buttocks are defined by a Y value
- Waterlines are defined by a Z value
- Diagonals are defined by the height (Z value) at which they cross the centerplane, and the angle from horizontal (in the Y-Z plane) (you can think of them as waterlines that have been heeled)
- Inclines are defined by the height (Z value) at which they cross the vertical axis at the origin, and the angle from horizontal (in the X-Z plane) (you can think of them as waterlines that have been rotated in profile view)
- Cants are defined by the longitudinal location (X value) at which they cross the longitudinal axis, and the angle from transverse (in the X-Y plane) (you can think of them as stations that have been rotated in plan view)

Orca3D gives you multiple ways to enter these values in the Sections dialog:

Add Sections

Define New Sections

Section Type Diagonals

List Locations meters

Group Definition

<input type="checkbox"/> Spacing	<input type="text"/> meters	Start	<input type="text"/> meters
<input type="checkbox"/> Number	<input type="text"/>	End	<input type="text"/> meters
<input type="checkbox"/> Update Bounding Box		Angle	<input type="text"/> Degree

Add
Preview
Import...

List Locations: Enter one or more values, separated by commas.

Group Definition:

Spacing: Enter the section spacing, together with Start and End values. Sections will begin at the Start value, and continue at the Spacing value until the End value is reached. For diagonals, inclines, and cants, the angle must be specified as well.

Number: Enter the number of sections, together with the Start and End values. The distance between Start and End will be divided into the Number of sections to determine the spacing. For diagonals, inclines, and cants, the angle must be specified as well.


Spacing and Number: Enter the Spacing and Number, together with the Start value. The Number of sections will be inserted with the specified Spacing, beginning at the Start location. For diagonals, inclines, and cants, the angle must be specified as well.

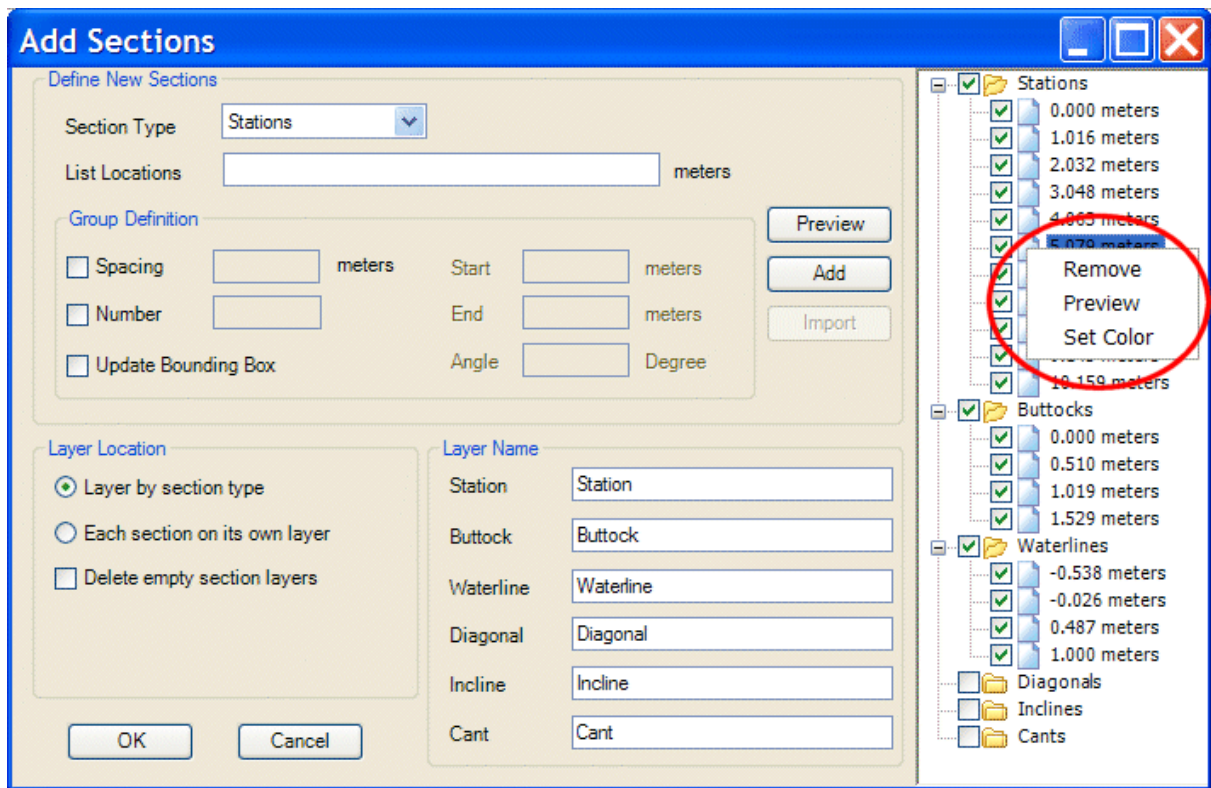
Update Bounding Box: When this box is checked, the Start and End values will be filled in automatically with the minimum and maximum values of the selected surface(s) in the appropriate dimensions (e.g., longitudinal min and max for stations and cants, transverse min and max for buttocks, vertical min and max for waterlines, diagonals, and inclines). As you select the different Section Types, these values will update.

9.3 Deleting Sections


Because Sections are associated with a surface, they cannot be directly edited or deleted. They will only change shape if the underlying surface is modified, and the only method of deleting a Section curve is to remove it from the sections list in the Sections dialog.

To remove a Section, select the surface(s) which are to be included in the calculation of

Sections. Open the Section dialog (, **Orca3D > Hull Design > Sections**, or **OrcaSections**), right-click on the section to be removed, and select Remove (you may right-click on a section type, such as Station, to delete all of the stations).



9.4 Refreshing Sections

Toolbar	 (right-click)
Menu	Orca3D > Hull Design > Sections
Command	OrcaSectionsRecompute


Sections are updated automatically when you modify a surface using the Orca control points. However, some other modifications may cause the sections to become out of synch with the surface(s). To refresh the sections, right click on the Sections icon on the toolbar, or enter the command **OrcaSectionsRecompute**. Orca3D remembers which surfaces were used when the sections were defined, and the sections will be recomputed through those surfaces.


9.5 Using Real Time Sections

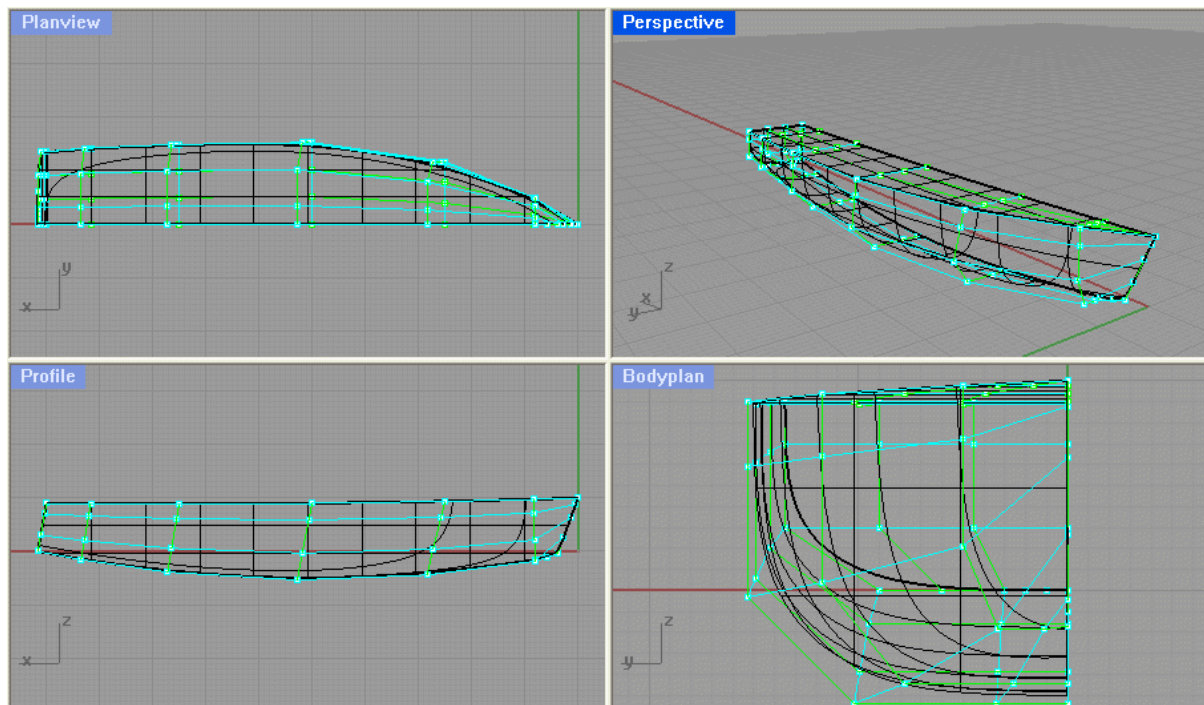
Orca3D can compute and draw the sections in real-time as a surface is modified. *This is only true if you are using Orca Control Points, rather than Rhino's standard control points.*

The first step is to [define sections](#)²³⁷. After that, simply use the Orca Control Points when editing the surface(s).

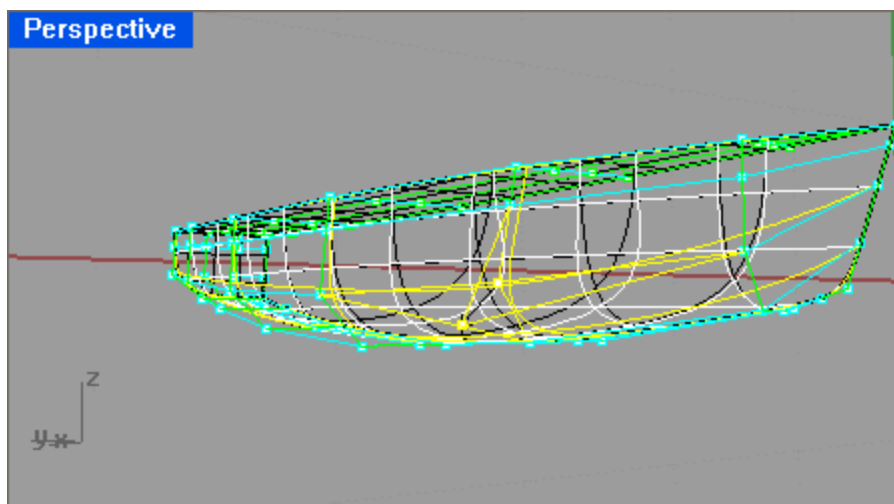
Orca Control Points

Toolbar	
Menu	Orca3D > Hull Design > Orca3D Control Points On
Command	OrcaPointsOn

1. Start the command from the toolbar, menu, or command line.
2. Select the surface(s) you wish to edit, and hit Enter.
3. The control points for the surface(s) will be shown. Orca control points, and the lines that connect them, are drawn differently than the standard Rhino control points. You may control the color of the lines in the control polygon in the Orca Properties dialog (). By default, control lines in the U direction (longitudinal, in general) are drawn in cyan, and the V direction (transverse, in general) are drawn in green.
4. Move the control points just as you would the Rhino control points. If you have defined Orca Sections, they will update in real-time (remember that the smoothness of the real-time curves is controlled by the smoothness of the Orca Mesh, which can be adjusted in [Orca Properties](#)⁸⁷⁾). If you have checked the Real-Time Hydrostatics box in the [Define Design Condition](#)¹³²⁾ dialog, you will also see a window showing the hydrostatics data updating.




Orca Control Points turned on



Moving an Orca control point with real-time section updating

9.6 Toggling Section Visibility

Toolbar	
Menu	n/a
Command	OrcaShowSection

Sometimes it can be useful to turn off the display of sections, without deleting them from the table of section locations that you have defined. The OrcaShowSection command can turn the visibility of Orca sections on and off.

To turn the visibility off, right-click on the OrcaShowSection toolbar icon; to turn the visibility on, left-click on the icon. Alternatively, use the command OrcaShowSection.

9.7 Scripting Sections

Sections Command Scripting Reference

Orca3D's Sections command can be scripted using Rhino's command scripting, and also using RhinoScript. Below the syntax of the command scripting is given.

Command Name: -OrcaSections (note that the "-" is required; otherwise the OrcaSections dialog will open)

Select type of section to create or <Enter> to finish (ClearAll Stations Buttocks Waterlines Diagonals Cants Inclines LayeringOptions):

Notes:

1. Must have one or more surface/polysurface/mesh objects selected
2. Lists of values use standard Orca3D list syntax; e.g. 0,1,...,10
3. The decimal separator must be a dot "." and the list separator must be the comma ","

Command Options:

ClearAll – deletes all currently defined sections

Stations - specify Station information

Add - enter location values for the Stations, separated by commas; the Orca3D list syntax may be used (e.g., 0,1,...,10,12,...,20)

ClearExisting - delete the existing Stations

LayerName or **LayerPrefix** - enter the name or the prefix (depending on the LayeringOptions setting) of the layer that the Stations are to be put on

Color - set the R,G,B value for the Station color

EnableDisable - toggle the calculation and drawing of Stations

Buttocks - specify Buttock information

Add - enter location values for the Buttocks, separated by commas; the Orca3D list syntax may be used (e.g., 0,1,...,10,12,...,20)

ClearExisting - delete the existing Buttocks

LayerName or **LayerPrefix** - enter the name or the prefix (depending on the LayeringOptions setting) of the layer that the Buttocks are to be put on

Color - set the R,G,B value for the Buttocks color

EnableDisable - toggle the calculation and drawing of Buttocks

Waterlines - specify Waterline information

Add - enter location values for the Waterlines, separated by commas; the Orca3D list syntax may be used (e.g., 0,1,...,10,12,...,20)

ClearExisting - delete the existing Waterlines

LayerName or **LayerPrefix** - enter the name or the prefix (depending on the LayeringOptions setting) of the layer that the Waterlines are to be put on

Color - set the R,G,B value for the Waterline color

EnableDisable - toggle the calculation and drawing of Waterlines

Diagonals - specify Diagonal information

Add - enter location values for the Diagonals, separated by commas; the Orca3D list syntax may be used (e.g., 0,1,...,10,12,...,20). First enter a list of heights, then an angle.

ClearExisting - delete the existing Diagonals

LayerName or **LayerPrefix** - enter the name or the prefix (depending on the LayeringOptions setting) of the layer that the Diagonals are to be put on

Color - set the R,G,B value for the Diagonal color

EnableDisable - toggle the calculation and drawing of Diagonals

Cants - specify Cant information

Add - enter location values for the Cants, separated by commas; the Orca3D list syntax may be used (e.g., 0,1,...,10,12,...,20). First enter a list of longitudinal locations, then an angle.

ClearExisting - delete the existing Cants

LayerName or **LayerPrefix** - enter the name or the prefix (depending on the LayeringOptions setting) of the layer that the Cants are to be put on

Color - set the R,G,B value for the Cant color

EnableDisable - toggle the calculation and drawing of Cants

Inclines - specify Incline information

Add - enter location values for the Inclines, separated by commas; the Orca3D list syntax may be used (e.g., 0,1,...,10,12,...,20). First enter a list of heights, then an angle.

ClearExisting - delete the existing Inclines

LayerName or **LayerPrefix** - enter the name or the prefix (depending on the LayeringOptions setting) of the layer that the Inclines are to be put on

Color - set the R,G,B value for the Incline color

EnableDisable - toggle the calculation and drawing of Inclines

LayeringOptions - Sections may be put on layers by their section type (i.e., all Stations on one layer, etc.), or each section may be put on its own layer.

LayerLocation - toggles between LayerByType and LayerBySection

DeleteEmptySection - Toggles between Yes and No. If set to Yes, any Orca Section layers that have been previously defined but are now empty will be deleted.

Part



10 Hydrostatics & Stability

This section describes the most common basic tasks you will use when computing hydrostatics and stability with Orca3D. It is designed as a "How-To" guide. You can use the table of contents as an index. Although it is organized roughly in the order that you would perform the tasks you don't need to begin at the beginning and work your way through. Every topic contains comprehensive links to background information and other relevant subjects so you can just pick out the task you need to perform and begin.

See also:

[Introduction](#) ⁷⁰

[Quick Start Tutorial](#) ⁹³

[FAQ-Hydrostatics & Stability](#) ⁴⁹⁰

10.1 Introduction

Orca3D performs hydrostatics and intact stability calculations on any combination of one or more Rhino surfaces and meshes. The flotation condition to be analyzed can be specified in two basic manners:

Input Type	Other Input	Result
Fixed Flotation Plane	Trim angle, Heel angle	Displacement and Center of Buoyancy
Fixed Weight	Trim angle or LCG, Heel angle or TCG	Equilibrium Flotation Plane

With both approaches, there is the option of analyzing stability over a range of heel angles, and a complete report of the hydrostatics and stability data is produced.

The process of computing hydrostatics and stability can be summarized as follows:


1. Define any [Points of Interest](#) ¹⁴⁴ (points on the model whose height above the waterline are tracked as the model heels, trims, and sinks)
2. Select the surface(s) and/or mesh(es) to be included
3. Define the flotation condition(s) to be analyzed
4. Review the report

If you are computing hydrostatics in the context of designing a hull, where you need to see results frequently and rapidly, but always with the same flotation condition (at the design

waterline, for example), Orca3D provides a special case of the hydrostatics command, called "Design Hydrostatics." In this case, the Design Condition is defined once (i.e. the surface(s) to be included, and the flotation plane or the weight/CG), and then the analysis can be run with a single button click, without having to define the surface(s) and flotation condition each time.

➔ *Note: It is assumed that the model's centerplane is at the plane where the transverse coordinate = 0 (for example, the Y=0 plane). Incorrect results will be reported otherwise.*

➔ *Note: Orca3D computes most of the hydrostatics parameters from the surface mesh, not in the traditional manner of integrating stations (stations are used for the sectional area curve, and the prismatic and maximum section coefficients). In general, this leads to more accurate results, and avoids the possibility of missing or mistreating features in the hull surface, such as the end of a hull skeg. The accuracy of the calculations, therefore, depends on the smoothness of the surface mesh (this is true in Rhino for other things; for example the curvature maps depend on the smoothness of the analysis mesh). To adjust the*

smoothness of the Orca3D mesh, use the **OrcaProperties** command, or the icon , and set the values in the Orca Mesh Parameters section. Also, please visit the [Mesh Density Accuracies](#)^[530] section of the [Verification and Testing](#)^[510] chapter, to see how various mesh settings affect the accuracy of the results.

10.2 The Model

Unlike traditional hydrostatics and stability software, Orca3D computes most of the parameters using a mesh that is generated from the surface(s), or simply a mesh model. In general, this leads to more accurate results, and doesn't rely on a station model of the hull that can easily miss features in the shape of the hull due to discontinuities, such as the end of a skeg.

Requirements

The requirements for a model are:

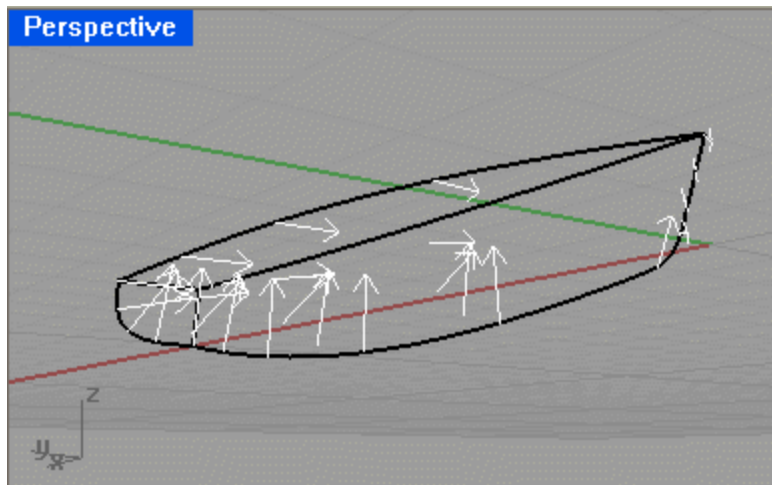
- May be composed of surfaces, polysurface, meshes, or any combination of these;
- While the model does not need to be completely sealed ("watertight"), any gaps in the model will decrease accuracy;
- The model's centerplane must be at the plane where the transverse coordinate = 0 (for example, the Y=0 plane). Incorrect results will be reported otherwise.
- Any naked edges should not become submerged; for example, if the model does not have a deck, it will not run at heel angles at which the deck edge would become submerged;

- The normal direction for ALL of the surfaces and mesh must point into the water. See below for information on how to check this, and change it if necessary;
- The surfaces and meshes being analyzed should only represent the outside shell of the vessel (hull, deck, superstructure, etc.), and not the interior surfaces (bulkheads, interior furniture, etc.);
- Be aware that interior surfaces, such as a cockpit, that are intersected by the waterplane and form a well, will be treated as if the well that is formed is filled with water, up to the waterplane. See the explanation of well surfaces below. *All selected geometry that is completely or partially below the waterplane, will be treated as if that portion of the geometry below the waterplane is wet.*

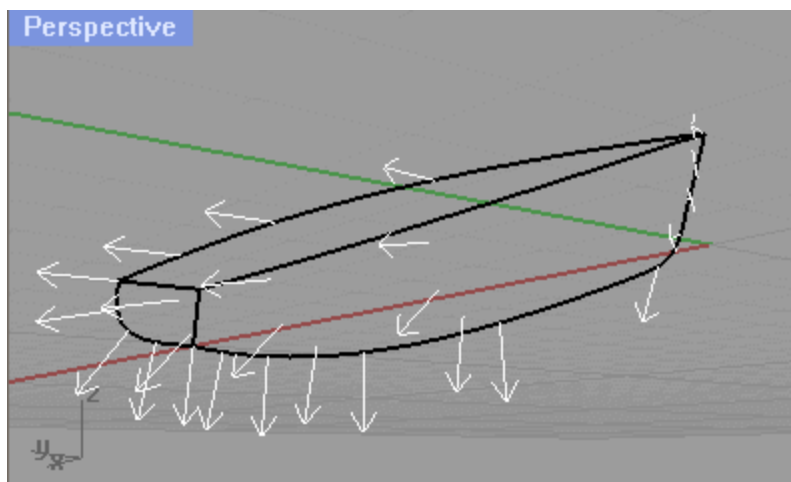
Orca3D computes most of the hydrostatic data from a surface mesh, not with the traditional approach of integrating stations. The user has control over the density of this mesh, just as you do with Rhino's display or analysis mesh. If the mesh is too coarse, your values will be low. If they are too high, it will slow down the computations without adding appreciable accuracy. The settings may be adjusted using the [OrcaProperties](#)^[77] command. You should experiment with different settings, and study their effect on your results. As you increase the density of the mesh, you will reach a point of diminishing returns in terms of increased accuracy versus computation time.

Normal Direction

Surfaces in Rhino have the concept of an "inside" and an "outside." The outside should be the side in contact with the water; if not, the volume of that surface will be computed to be negative. If your model consists of multiple surfaces (not joined), and some of them have the outside direction incorrect, they will deduct from the total. There are two ways to visualize the outside direction of a surface; first, you can select the Direction command from Rhino's Analyze menu. Arrows will be drawn in the outward direction, and so should point into the water (note that for surfaces such as bow thruster tunnels, this means that the arrows will be pointing into the interior of the cylinder). If you find a surface whose direction is incorrect, use the Flip option in the Direction command to flip it to the correct direction.



Incorrect Direction on the hull surface



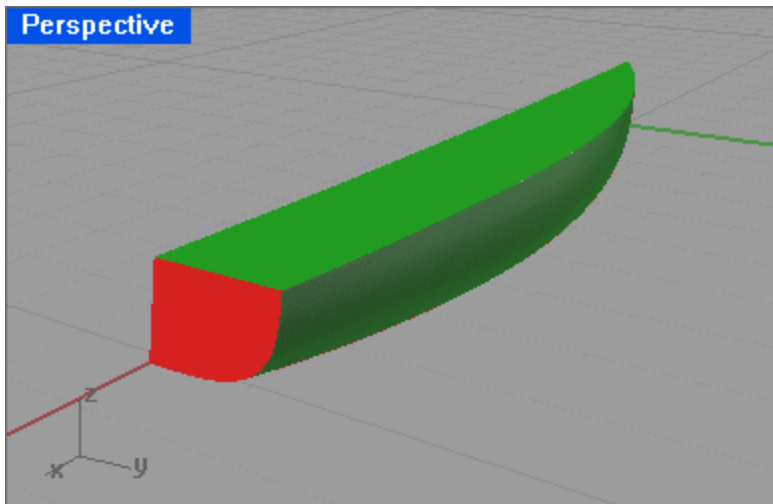
Direction corrected with the Flip option

If you have many surfaces, this can become tedious; a more effective way to quickly see the directions of the surfaces is to use Rhino's Backface Settings.

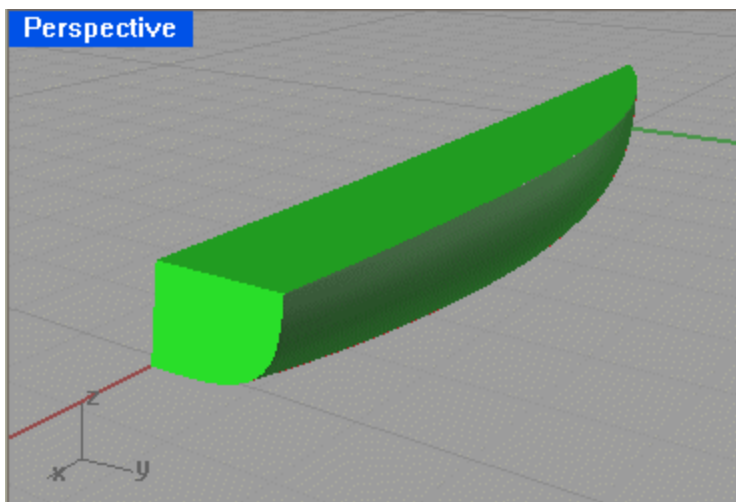
In Rhino 4: Select the Perspective viewport, and change to a shaded rendering. Right-click on the viewport title (Perspective), and select Display Options from the menu. Go to Rhino Options/Appearance/Advanced Settings/Shaded, and select Shaded. For the Backface Settings option, select "Single Color for all backfaces," and then select a color that stands out in your model.

In Rhino 5: Select the Perspective viewport, and change to a shaded rendering. Right-click on the viewport title (Perspective), and select Display Options from the menu. Go to Rhino Options/View/Display Modes/Shaded, and change Backface settings to "Single Color for all backfaces" and then select a color that stands out in your model.

Now, as you rotate the model, you can quickly visualize the backface (inside) of each of your surfaces. You can now use the Flip command to flip the direction of any surfaces that are incorrect. In the example below, the surface color is set to green, and the backface color is set to red.



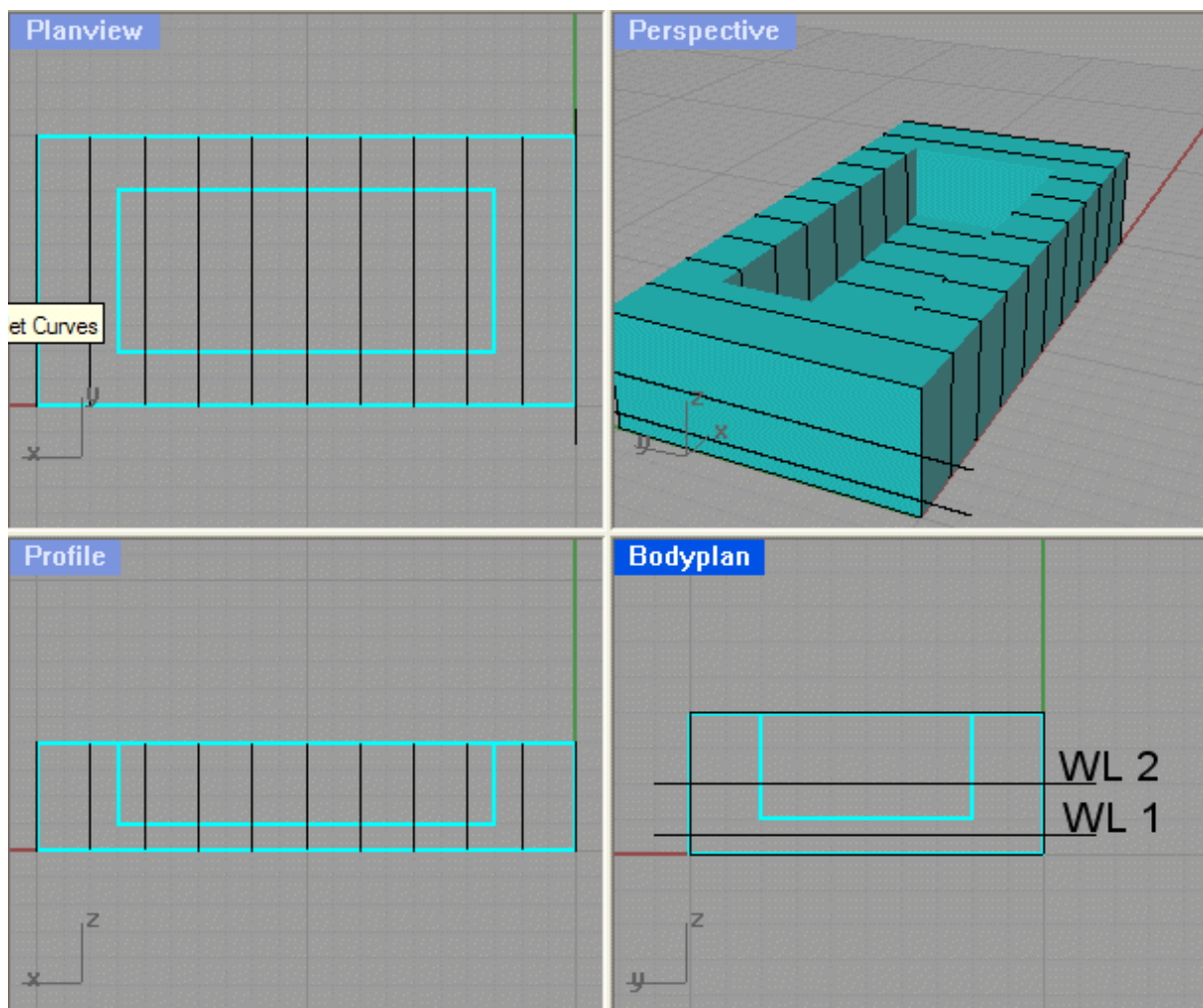
Incorrect Direction on the transom surface



Direction corrected with the Flip option

Well Surfaces

All selected geometry that is completely or partially below the waterplane, will be treated as if that portion of the geometry below the waterplane is wet. This issue, which occurs with any hydrostatics program, will occur when the model includes surfaces that are below the waterplane, but would normally be dry. In the following barge-like example, because the interior of the barge has been modeled, there is potential for error:



In the case of WL 1, which is below the inside deck of the barge, the results will be fine. However, if hydrostatics are run at WL2, the results will be as if the interior of the barge were flooded up to WL2.

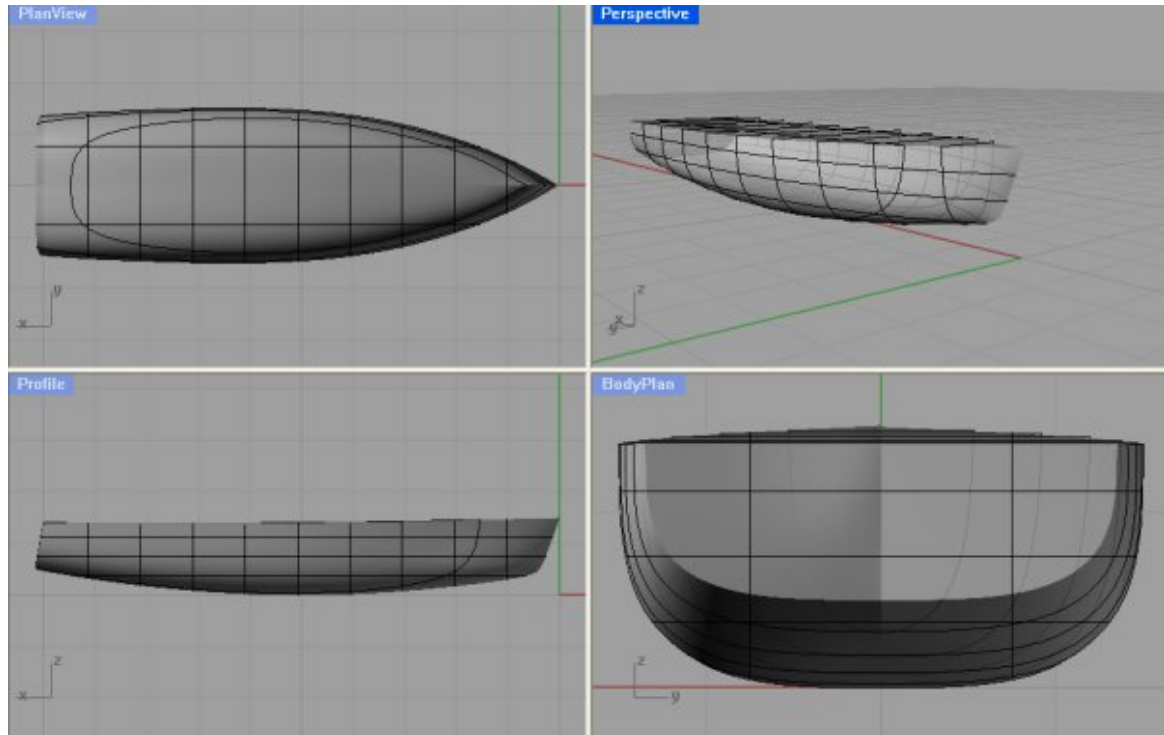
Note that this can occur not just in the upright condition, but also in a heeled condition. For example, beginning at WL1 for this barge at 0 degrees of heel would be fine; however, at some heel angle the waterplane is likely to intersect the inside deck, and cause it to be considered flooded.

In cases like this, it is best to select only the outside surfaces of the model when running hydrostatics.

10.3 Heel, Trim and Sinkage

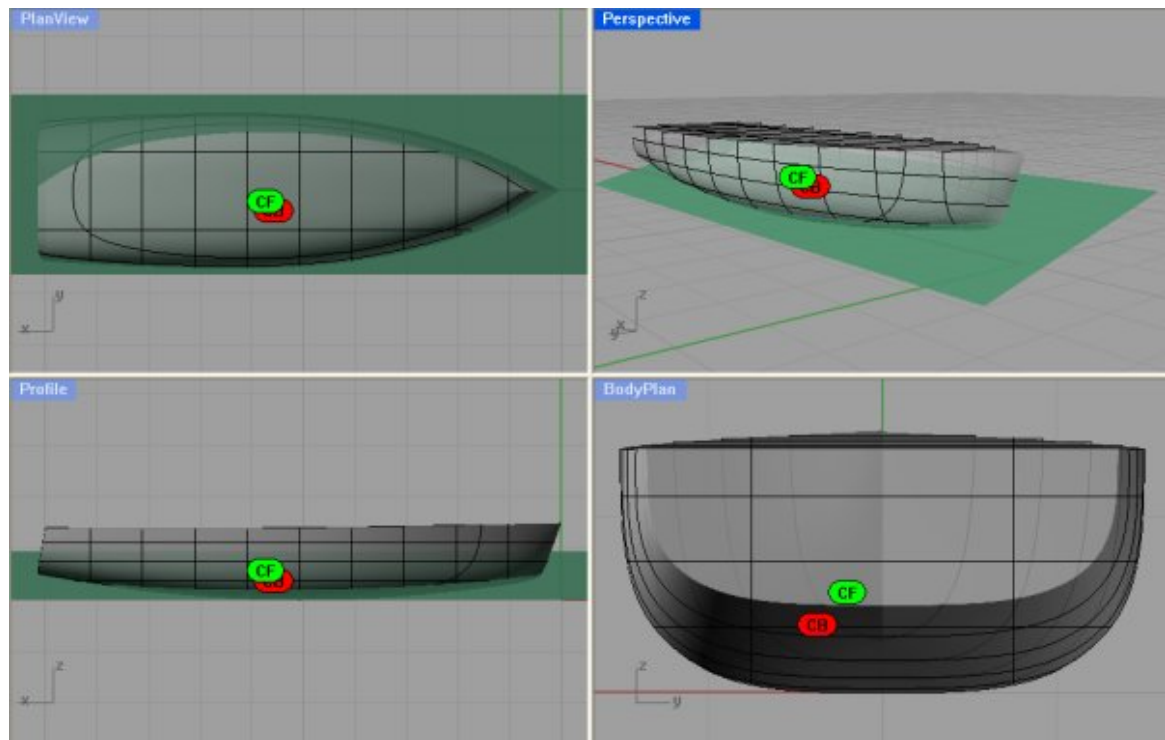
To understand the input and output conventions of the hydrostatics and stability calculations of Orca3D, it helps to picture **the model moving within a fixed world coordinate system** (rather than the waterplane moving and the model remaining fixed).

This image shows a sailboat hull, with $Z=0$ at the bottom of the hull.

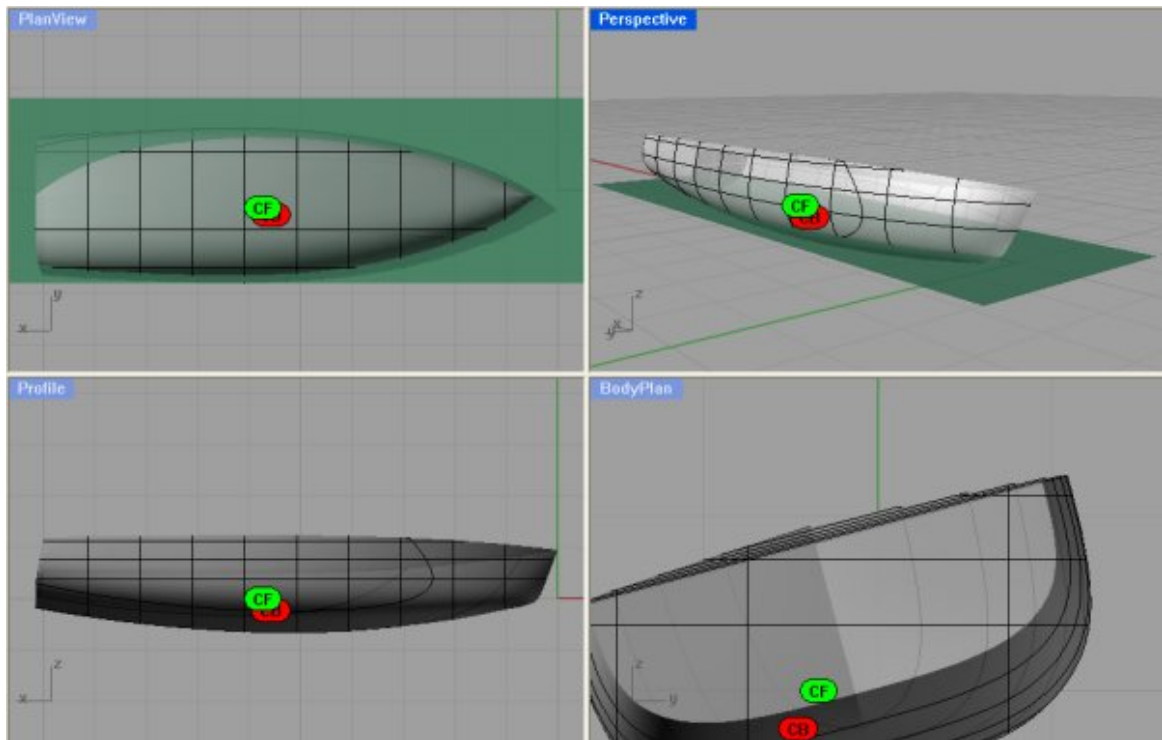


After running hydrostatics with a Sinkage of 0.5 meters and a Heel angle of 15 degrees, there are two options for graphically viewing the resulting flotation condition of the model:

- **Add Plane(s) representing water surface:** This option is convenient because the model is not moved in the world coordinate system, but it can lead to some confusion because it shows the boat remaining fixed and the waterplane moving. Note that the model baseline is still at $Z=0$, and that the plane representing the equilibrium flotation plane is not parallel to the $Z=0$ plane. The advantage of this view is that it's very easy to visualize the heeled waterline and the attitude of the model in this condition, and the plane can be easily deleted without worrying about having moved the model in the world coordinate system.



- **Transform model to resultant condition:** This option moves the model in a way that reflects how the calculations are actually carried out. The waterplane remains fixed in the Rhino coordinate system, and the model heels, trims, and sinks until it is in equilibrium. While this is more intuitive, you may not want to have your model move in the Rhino coordinate system every time you compute hydrostatics. ***But when interpreting the input and output data, this is how you should visualize the process.***

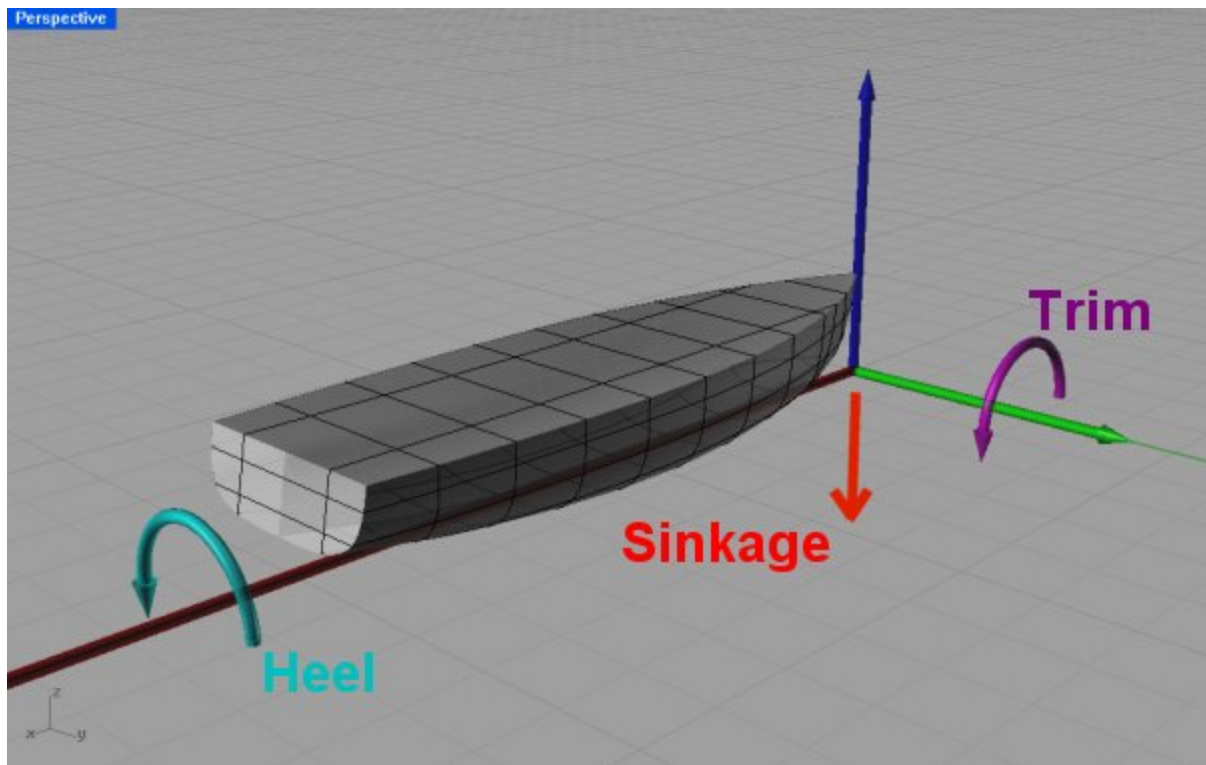


When defining a flotation condition or interpreting the output data, we use the terms Heel, Trim, and Sinkage:

Heel: the heel angle of the vessel, in degrees, about the world longitudinal axis

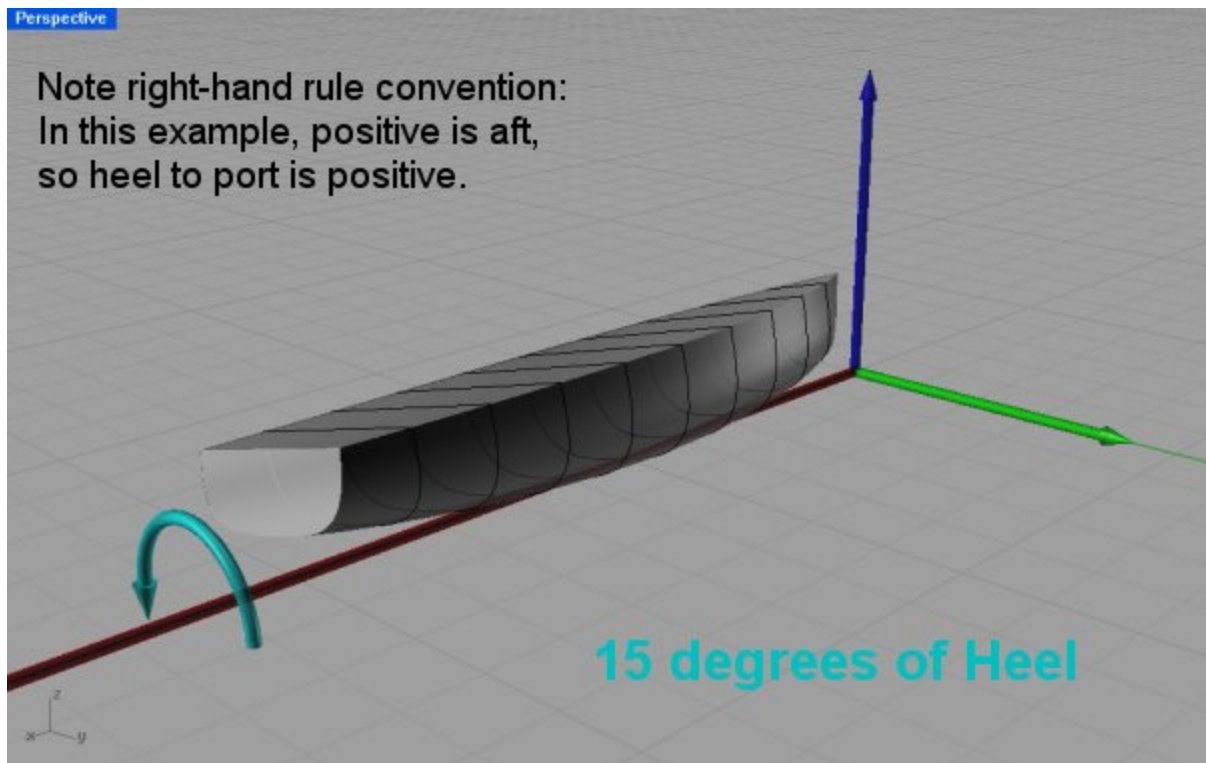
Trim: the trim angle of the vessel, in degrees, about the world transverse axis (note that if there is heel, this is *not* the trim in the boat's axis)

Model Sinkage: the depth of the world origin below the resultant flotation plane, perpendicular to the resultant flotation plane. Positive sinkage is defined as the origin being below the flotation plane. This is sometimes referred to as "origin depth."

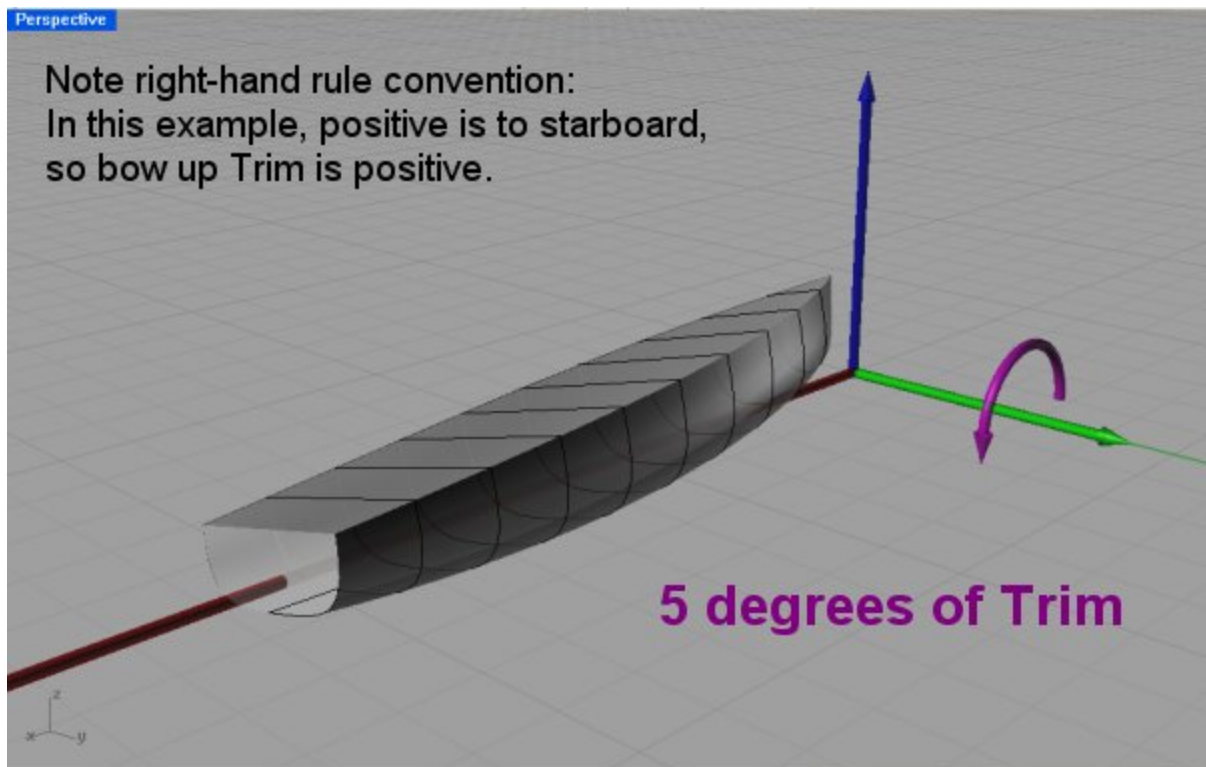


In the figure above, the vessel is in its original orientation. If we were to specify a Heel of 15 degrees, a Trim of 5 degrees, and a sinkage of 0.5 meters, the program would go through these steps to transform the model before computing the hydrostatics:

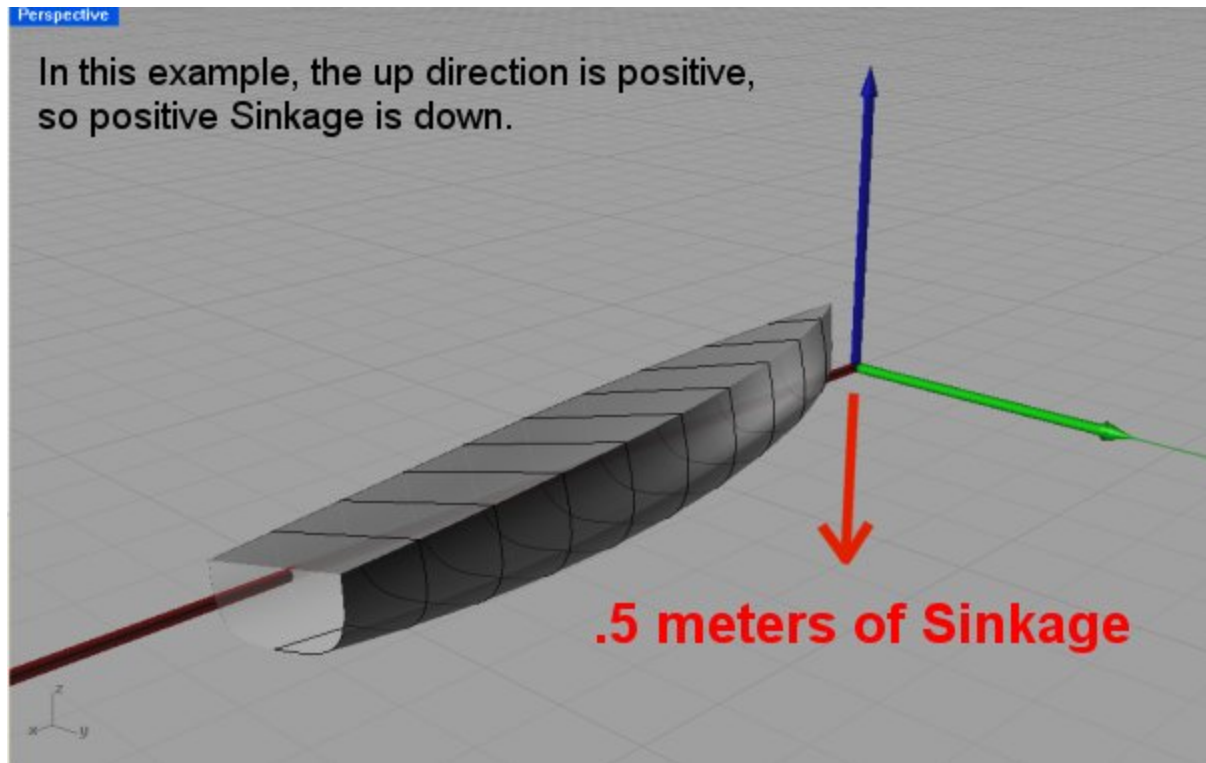
1. First, the boat is heeled about the world longitudinal axis.



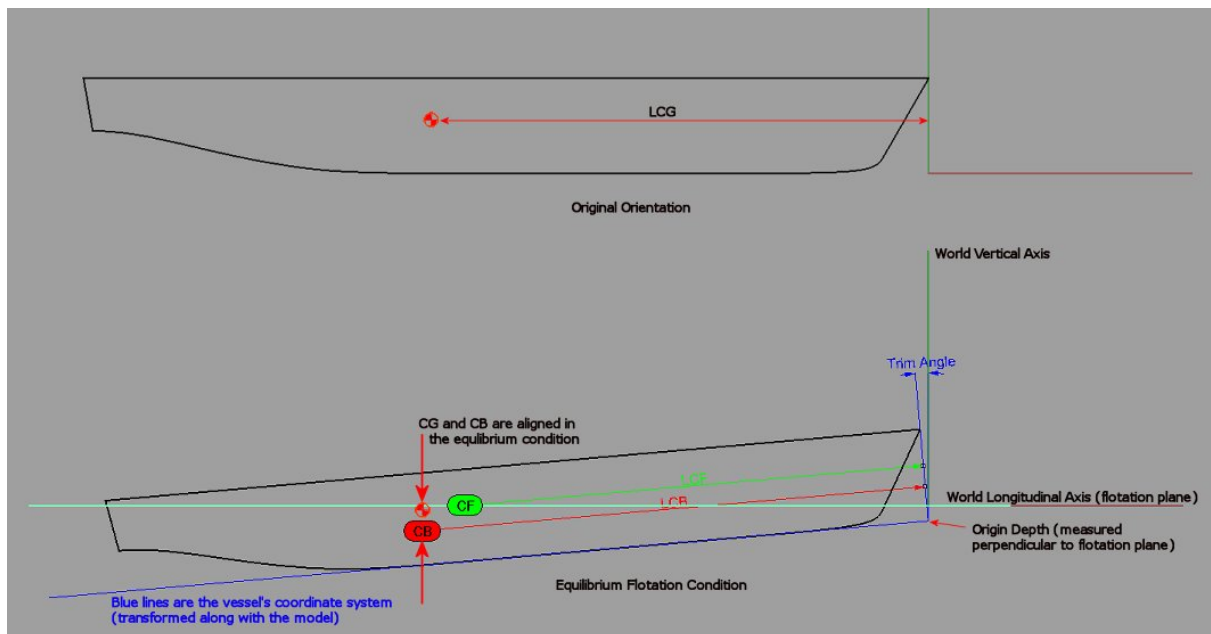
2. Next, the boat is trimmed about the world transverse axis. Note that if the boat was heeled, this will not be the same as "trim" in the boat's coordinates; in other words, a trim inclinometer mounted on a bulkhead on the boat would not match this value.



3. The boat is moved up or down along the world vertical axis by the sinkage amount.



The next figure shows the model moving in the Rhino coordinate system, from its original orientation to the equilibrium flotation condition. The center of gravity location (LCG, TCG, VCG) is specified by the user in the Rhino coordinate system. When Orca3D reports the center of buoyancy in the output, it is in the vessel's coordinates (as if the original coordinate system has been transformed along with the model). Thus the reported LCB may not match the input LCG, even though physically the two are vertically aligned in the equilibrium condition.



10.4 Sign Conventions

For various purposes, Orca3D must know which coordinate axis is longitudinal, which is transverse, and which is vertical, and further, what direction the positive sense of each of these corresponds to. For example, the definition of a "station" is a plane at a constant X value, if X is your longitudinal coordinate. And while the direction (positive X aft or forward) doesn't matter for hydrostatics calculations, it is important for speed/power analysis (the program needs to know which end is the bow). Orca3D defaults to a coordinate system with positive X aft, positive Y to starboard, and positive Z up. However, you can set the coordinates in any of 24 combinations, all of which are right-hand rule coordinate systems.

- **Fwd is:** Select the coordinate direction that corresponds to the "Forward" direction in your model.
- **Up is:** Select the coordinate direction that corresponds to the "Up" direction in your model.

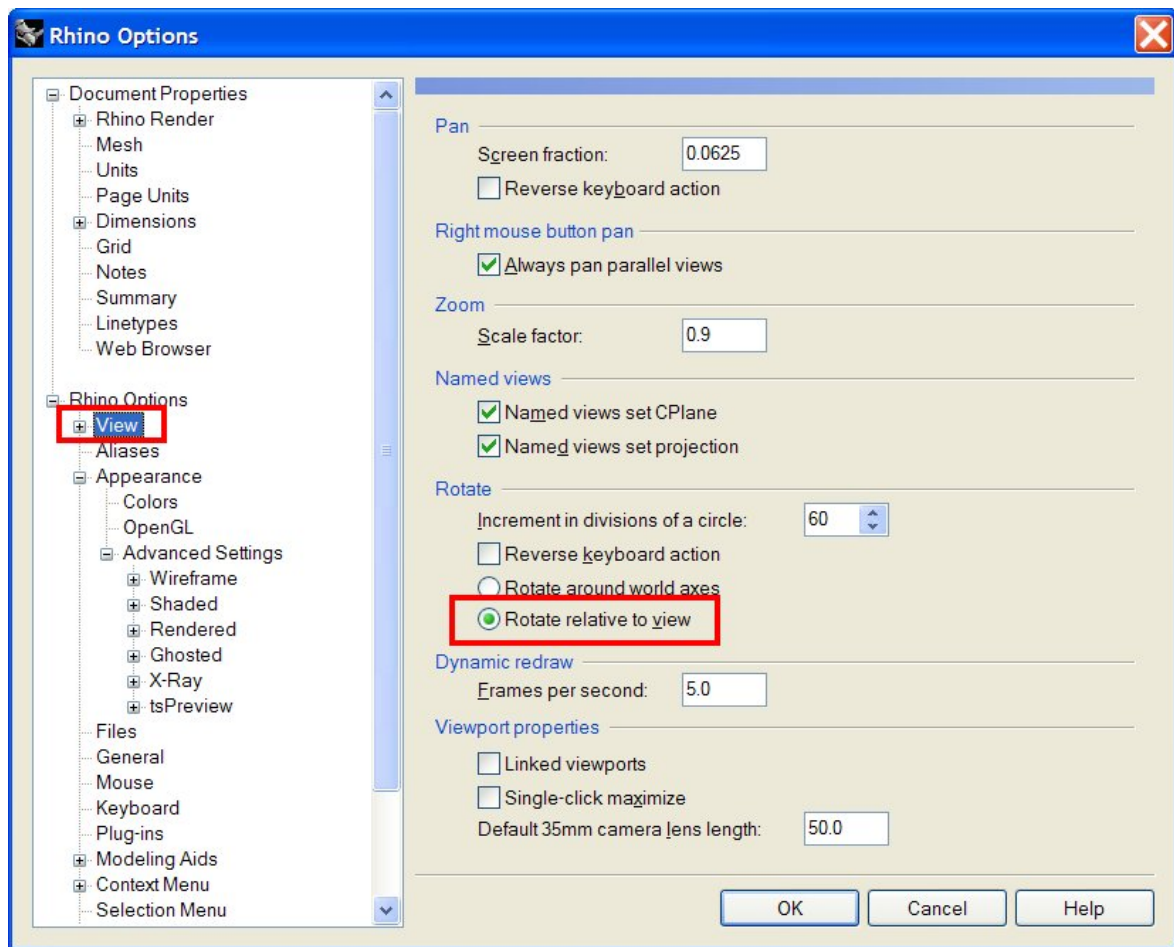
Note: Changing these values will not rotate your model. You must use the standard Rhino commands (Rotate or ScaleNU) to change the orientation of your model.

Orca3D always maintains a right-handed coordinate system. This implies the following:

If Fwd is set to	...and Up is set to	...then Starboard is	...and positive Trim is	...and positive Heel is to
Positive X	Positive Z	Negative Y	Bow down	Starboard

Positive X	Negative Z	Positive Y	Stern down	Starboard
Positive X	Positive Y	Positive Z	Stern down	Starboard
Positive X	Negative Y	Negative Z	Bow down	Starboard
Negative X	Positive Z	Positive Y	Stern down	Port
Negative X	Negative Z	Negative Y	Bow down	Port
Negative X	Positive Y	Negative Z	Bow down	Port
Negative X	Negative Y	Positive Z	Stern down	Port
Positive Y	Positive Z	Positive X	Stern down	Starboard
Positive Y	Negative Z	Negative X	Bow down	Starboard
Positive Y	Positive X	Negative Z	Bow down	Starboard
Positive Y	Negative X	Positive Z	Stern down	Starboard
Negative Y	Positive Z	Negative X	Bow down	Port
Negative Y	Negative Z	Positive X	Stern down	Port
Negative Y	Positive X	Positive Z	Stern down	Port
Negative Y	Negative X	Negative Z	Bow down	Port
Positive Z	Positive X	Positive Y	Stern down	Starboard
Positive Z	Negative X	Negative Y	Bow down	Starboard
Positive Z	Positive Y	Negative X	Bow down	Starboard
Positive Z	Negative Y	Positive X	Stern down	Starboard
Negative Z	Positive X	Negative Y	Bow down	Port
Negative Z	Negative X	Positive Y	Stern down	Port
Negative Z	Positive Y	Positive X	Stern down	Port
Negative Z	Negative Y	Negative X	Bow down	Port

If you choose a coordinate system with the Up direction set to a Negative direction, you may find that rotating the view in the Perspective viewport is non-intuitive. This is because by default, Rhino does rotations about the World Coordinates. To make it more intuitive, open the Rhino Options dialog (Tools > Options, or right-click on a viewport name and select Display Options). Click on View, and then select "Rotate relative to view."



10.5 Defining the Flotation Condition(s)

Orca3D provides a lot flexibility when running hydrostatics and stability analyses. Analyses can be run assuming that you know the displacement (weight), or assuming that you know the waterplane. The flotation condition can be specified with any one of the following combinations:

- Weight, LCG, TCG
- Weight, LCG, Heel
- Weight, Trim, TCG
- Weight, Trim, Heel
- Model Sinkage, Trim, Heel

In addition, a planar surface in the Rhino model can be used to define the flotation plane. One way to create this plane is with the Create Float Plane command, which allows you to enter freeboard or draft measurements at one, two, or three locations.

Definition of Terms

Following are the required inputs for an analysis, which define the flotation plane. More than one flotation condition can be specified, by listing values in each input field.

Note that these values define the equilibrium flotation plane, and in the case of entering a heel or trim, are used to determine the center of gravity. If a range of heel angles is also entered, the 0 degree condition is taken as the original model orientation, not the equilibrium flotation plane. If a non-zero TCG or a non-zero Model Heel are entered, there will be a non-zero righting arm at 0 degrees of heel. Zero righting arm will correspond to the heel angle at the equilibrium flotation plane.

Orca3D Hydrostatics & Stability Analysis

Description: Hydrostatics & Stability Analysis

☐ Weight(s) 0 kgf or ☒ Model Sinkage(s) 0.118 m
☐ LCG(s) 0 m or ☒ Model Trim(s) -1.109 deg
☐ TCG(s) 0 m or ☒ Model Heel(s) 0.000 deg
 VCG(s) 0 m

☐ Override Initial Plane Height for Free Float Iteration 0.249999999999998 m
☒ Mirror About Centerplane
☒ Add Plane(s) Representing Water Surface
☐ Transform Model to Resultant Condition
☐ Compute Righting Arm at these Heel Angles 0 e.g. 0.5,...,30,40,...,90
☐ Print Full Output for Heeled Conditions
☐ Also Write Output To CSV File C:\Users\bhays\Documents\Hydrostatics.csv
☐ Use Custom Conditions
 Sort Results By: Displacement

Pre-Float Calculate Cancel Add Objects... Points of Interest... Orca3D Units...

Weight: the overall weight of the vessel, in the units shown

If you have chosen the Weight option (rather than Model Sinkage), you may also click on the "Weight/Cost" icon, and the total weight and center of gravity will be computed from the objects in the model that have weight properties, and the values filled in to the Weight, LCG, TCG, and VCG fields (this option requires that you have

Orca3D Level 2, which includes the Weight/Cost Tracking module). Note that these values represent only what is explicitly modeled (it does not double the weight when you check Mirror About Centerplane, for example), and only the objects that have Weight properties assigned to them. If you have only modeled half of the hull, you should double the Weight value, and (presumably) move the TCG to 0. Note: this is not a permanent link. You must click the icon each time you wish the values to be updated.

You can manually compute the overall weight and CG of a number of items using the Calculator icon. For example, if you know the weight and CG of the lightship, crew & effects, and fuel, you can enter each of them individually, and the sum will be entered into the appropriate fields in the Hydrostatics dialog.

The Orca3D Weight Calculator dialog box contains a table with the following data:

Name	Weight (kgf)	LCG (m)	TCG (m)	VCG (m)
LightShip	12500	6.5	0	0.75
Crew & Effects	500	6.2	0	1
Fuel	200	7.3	0	0.25
New Item	0	0	0	0

Below the table, the Totals are displayed:

	Weight (kgf)	LCG (m)	TCG (m)	VCG (m)
Totals	13200.000	6.501	0.000	0.752

Buttons at the bottom include OK, Cancel, Add Item, and Delete Item(s).

LCG: the longitudinal center of gravity of the vessel, in the current length units, from the world origin

TCG: the transverse center of gravity of the vessel, in the current length units, from the world origin

VCG: the vertical center of gravity of the vessel, in the current length units, from the world origin (this is required in order to run a stability analysis at one or more heel angles)

Model Sinkage: the depth of the world origin below the resultant flotation plane, perpendicular to the resultant flotation plane. Positive sinkage is defined as the origin being below the flotation plane. This is sometimes referred to as "origin depth."

Trim: the trim angle of the vessel, in degrees from the horizontal plane in the world coordinates. A right-hand coordinate system is used, so that if positive Y to starboard, a positive trim angle is bow up

Heel: the heel angle of the vessel, in degrees from the horizontal plane in the world coordinates. A right-hand coordinate system is used, so that if positive X is aft, a positive heel angle is to port

Notes on Entering Multiple Conditions

In all of the fields in the Hydrostatics & Stability dialog (except "Override Initial Plane Height"), you may enter a list of values, separated by commas or ellipses (...). For example, a list of Model Sinkages might be

1,2,3,4,5

As a shorthand, you may also enter the following to get the same list:

1,2,...,5

The spacing implied by the two numbers before the ellipses will be used until the number after the ellipses is reached or exceeded (*note the commas before and after the ellipses*). Multiple spacings may be entered, as in the following example for heel angles:

0,5,...,30,40,...,90,120,...,180

This is equivalent to entering:

0,5,10,15,20,25,30,40,50,60,70,80,90,120,150,180.

The matrix of flotation conditions that will be computed is created from all of the combinations of the various entries. For example, if you enter:

Model Sinkage: 1, 2, 3

Model Trim: 1.5, 2.5

Model Heel: 5, 10

12 flotation conditions will result.

Select Float Plane

If you have a plane in the model that represents the flotation plane, click the "Select Float Plane" button and then select the plane in the model. The sinkage, trim, and heel values corresponding to that plane will be filled in.

The plane can be created using the "Create Float Plane" selection in the Hydrostatics and Stability menu (or by typing the command `OrcaCreateFloatPlane`). This command allows the user to define a plane (representing a measured flotation plane) from one, two, or three freeboard or draft measurements. For each measurement, the command requests input of

the reference location of the measurement (such as a transom corner or deck location where the measurement was made from) and the measurement to the water surface. If only one point is specified, the flotation plane is assumed to be a zero trim/zero heel plane. If two points are specified, the plane is assumed to be either zero trim or zero heel depending on the relationship of the first and second reference points. Finally, if three measurement points are specified a general plane with heel and trim is created. The resulting plane is added to the Rhino model so that it can be used as input to a hydrostatics calculation.

Optional Inputs

Description: This field will be included in the output for the analysis

Override Initial Plane Height for Free Float Iteration: When a Weight is specified (a Free Float condition), Orca3D must make an initial calculation at some waterplane to use as a starting point. Once the displacement and center of buoyancy have been determined at this initial guess, the program iterates sinkage, trim, and heel to converge to an equilibrium condition (weight=displacement, centers of gravity and buoyancy are aligned). The Initial Plane Height defaults to the vertical midpoint of the model in its current orientation. This usually works well, but in some models this will be a poor guess; for example, if a sailboat model has a deep keel, so that the initial guess is somewhere in the keel, it will be more difficult (and time consuming) for Orca3D to converge properly. In these cases, you can check this box, and enter a height that is closer to the equilibrium waterplane height.

Mirror About Centerplane: checking this box assumes that you have modeled half of a symmetric hull, and wish the program to assume the mirror image. Note that hulls that are not centered at $Y=0$ will give incorrect results; therefore a symmetric catamaran hull model, where only one side of each hull has been modeled, should be moved to the centerplane before analyzing it.

Add Plane(s) Representing Water Surface: checking this option will insert a planar surface to represent each equilibrium flotation condition, and will include markers representing the centers of buoyancy and flotation. It will also include a plot of the sectional area curve, if [stations](#)^[237] have been defined. The scale and color of this curve may be set in Orca3D Document Properties, in the [Hydrostatics tab](#)^[86]

Transform Model to Resultant Condition: This option will cause the model to be moved (only that portion of the Rhino model that was selected for the hydrostatics calculation). The model is first heeled about the world longitudinal axis, then trimmed about the world transverse axis, then sunk along the world vertical axis. *Note that output results (such as VCB) are reported in the coordinate system of the original model orientation.*

Compute Righting Arm at these Heel Angles: When selected, you may enter a list of heel angles to be analyzed, separated by commas. A list of evenly spaced values may be entered in the format a, b, \dots, c where a is the first angle, c is the final angle, and intermediate angles will be included at a spacing of $(b-a)$.

Note that the 0 degree condition is taken as the original model orientation, not the equilibrium flotation plane. If a non-zero TCG or a non-zero Model Heel are entered, there will be a non-zero righting arm at 0 degrees of heel. Zero righting arm will correspond to the heel angle at the equilibrium flotation plane.

The calculation of the righting arm allows the model to trim as it heels to maintain a true hydrostatic balance (this is true even if a Model Trim was entered to define the equilibrium flotation plane; the Model Trim is used to determine the center of gravity, which is then used as the model is heeled).

The value of the heel angles must be between -180 to 180 degrees.. For example:

0,10,...,180 will compute every 10 degrees from 0 to 180

or

0,-20,...,-60 will compute every 20 degrees from 0 to -60

or

-150,-140,...,0,5,...,60 will compute every 10 degrees from -150 to 0, then every 5 degrees from 0 to 60

Print Full Output for Heeled Conditions: By default, the output does not include a complete table of hydrostatic data at each heeled condition. Checking this box will cause the complete hydrostatic data to be included in the report for each heel angle.

Also Write Output to CSV File: If you also want output written to a comma-separated-value (CSV) format (suitable for import into Excel, or parsing with another program), check "Also Write Output to CSV File," and enter the path and filename. The format of this file is self-documenting. If the "Print Full Output for Heeled Conditions" is also checked, extended information for each heel angle will be included.

Use Custom Conditions: Defining multiple conditions at once is easy in Orca3D, by simply entering a list of values in the various fields. For example, if you specify Sinkage values of 1.0, 1.1, and 1.2, Trim values of 0 and 1, and Heel values of 2 and 4, Orca3D will run the 12 combinations of these values (3 Sinkages x 2 Trims x 2 Heels). However, you may only wish to run a few of these combinations, and at the same time include a few conditions that are defined by Weight, LCG, and TCG. In this case, check the "Use Custom Conditions" check box, and the following table will be shown in the Hydrostatics & Stability dialog. The table will be initially populated with all of the various combinations of the values in the selected input fields (e.g., Weight, Model Sinkage, etc.). By default, the conditions are sorted in the output according to Displacement, but you may specify that the results are sorted by draft, trim, or heel. This table may also be populated by copying data from Excel and pasting it into the grid (right click on the grid and select Paste). The data must have 10 columns matching the format of the grid (the Run check box should be 1 for checked, 0 for not checked). You may also copy data from the grid (right click and select Copy) and paste it into Excel.

Run	Name	Type	Weight	LCG	TCG	VCG	Sinkage	Trim	Heel
<input checked="" type="checkbox"/>	Condition 1	Fixed Plane				0	1	0	2
<input checked="" type="checkbox"/>	Condition 2	Fixed Plane				0	1	0	4
<input checked="" type="checkbox"/>	Condition 3	Fixed Plane				0	1	1	2
<input checked="" type="checkbox"/>	Condition 4	Fixed Plane				0	1	1	4
<input checked="" type="checkbox"/>	Condition 5	Fixed Plane				0	1.1	0	2
<input checked="" type="checkbox"/>	Condition 6	Fixed Plane				0	1.1	0	4
<input checked="" type="checkbox"/>	Condition 7	Fixed Plane				0	1.1	1	2
<input checked="" type="checkbox"/>	Condition 8	Fixed Plane				0	1.1	1	4
<input checked="" type="checkbox"/>	Condition 9	Fixed Plane				0	1.2	0	2
<input checked="" type="checkbox"/>	Condition 10	Fixed Plane				0	1.2	0	4
<input checked="" type="checkbox"/>	Condition 11	Fixed Plane				0	1.2	1	2
<input checked="" type="checkbox"/>	Condition 12	Fixed Plane				0	1.2	1	4
<input type="checkbox"/>									

Here, you can turn a condition off by unchecking its box in the Run column, and change its name by double-clicking its entry in the Name column (this name will be displayed in the report). New entries may be added at the bottom of the list.

There are two Types available; "Fixed Plane" (Sinkage, Trim, and Heel), and "Free Float" (Weight, LCG or Trim, TCG or Heel). By clicking on the Type for a condition, you can select the type:

Run	Name	Type	Weight	LCG	TCG	VCG	Sinkage	Trim	Heel
<input checked="" type="checkbox"/>	Condition 1	Fixed Plane				0	1	0	2
<input checked="" type="checkbox"/>	Condition 2	Free Float				0	1	0	4
<input checked="" type="checkbox"/>	Condition 3	Fixed Plane				0	1	1	2
<input checked="" type="checkbox"/>	Condition 4	Fixed Plane				0	1	1	4
<input checked="" type="checkbox"/>	Condition 5	Fixed Plane				0	1.1	0	2

Once this is selected and you have moved the cursor to one of the fields, the fields that will not be used are shown in gray. In the example above, Condition 2 has been changed to a Free Float condition, so Sinkage is now gray (even though a value is entered in the field, it will not be used). At this point, you can enter the Weight. Next, enter **either** the LCG or Trim. The same is true for TCG and Heel. Finally, enter the VCG. If you enter both, a warning will be given when you move to a different row in the table or try to Calculate, and the fields in question will be highlighted in yellow, and you will need to clear one field or the other. In the example below, Condition 2 has been changed to a Free Float. A Weight has been entered (the Sinkage value is now ignored), and a TCG has been entered. However, there is still a Heel value entered, and you must choose between one or the other by clearing the entry of one of them.

☐ Add Plane(s) Representing Water Surface
☐ Transform Model to Resultant Condition
☐ Compute Righting Arm at these Heel Angles
☐ Print Full Output for Heeled Conditions
☐ Also Write Output To CSV File
☒ Use Custom Conditions

Calculate Cancel Add Objects... Points of Interest... Orca3D Units...

Custom Condition Definition Error

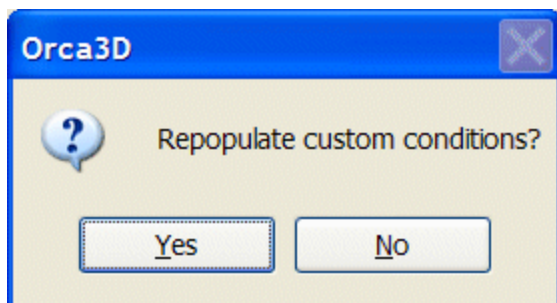
Errors occurred during definition of conditions:
Enter a valid double for tcg OR heel for "Condition 2".

OK

Run	Name	Type	Weight	LCG	TCG	VCG	Sinkage	Trim	Heel
<input checked="" type="checkbox"/>	Condition 1	Fixed Plane				1	1	0	2
<input checked="" type="checkbox"/>	Condition 2	Free Float	1000		0.5	2	1	0	2
<input checked="" type="checkbox"/>	Condition 3	Fixed Plane				1	1	1	4

You may only enter the TCG OR the Heel, not both.

If you uncheck the "Use Custom Conditions" check box, and then re-check it, the following prompt will appear:

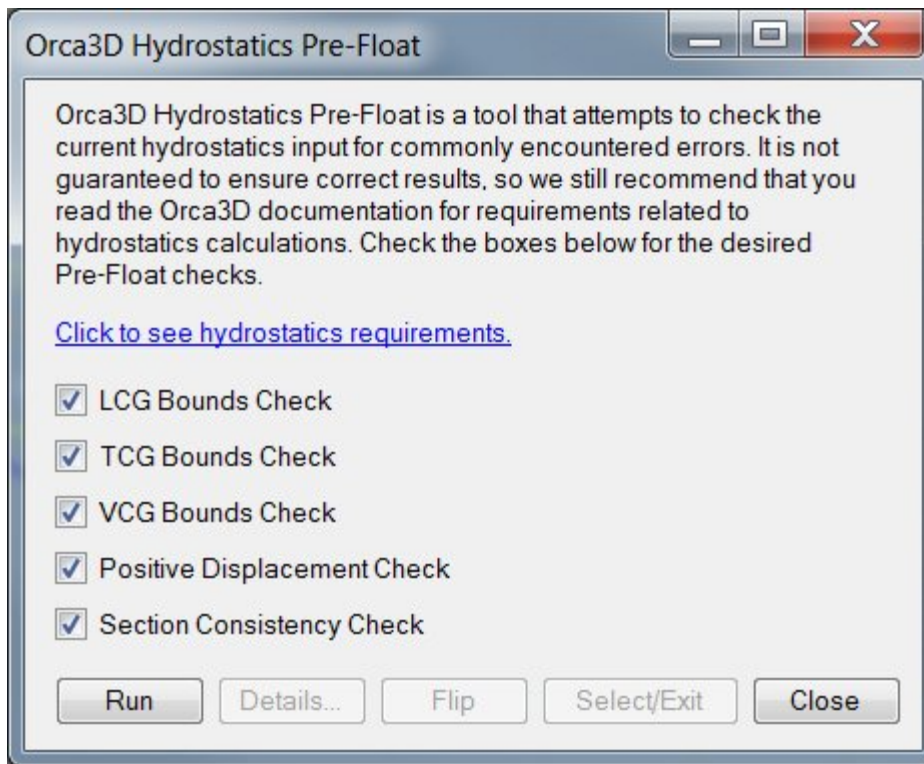


If you answer Yes, the form will be repopulated using the values in the fields of the Hydrostatics & Stability dialog (any custom conditions will be lost). If you answer No, the form will be shown with your previous data.

You may also copy/paste data to/from the clipboard into the custom conditions control in the Hydrostatic form. A typical source of this data might be a spreadsheet table or a CSV file. The data must have 10 columns matching the format of the data in the grid (including empty cells/data in columns where no numbers should be copied). After placing the data to copy into the Windows clipboard, right click on the custom conditions grid control and choose Paste from the pop-up menu.

Pre-Float: Clicking this button will execute an analysis to look for commonly encountered errors. While it doesn't guarantee to discover all potential sources of error, it can find things such as CG locations outside of the bounds of the hull, negative displacement due to [incorrect outward normals](#)²⁴⁹, and section definitions that are not consistent with the selected surfaces.

After clicking Run, the status of each check will be shown. If any of the checks fail, the status will be shown as "See Details." Click the Details button to get further information on how to rectify the situation.



- **LCG, TCG, VCG Bounds:** check to be sure that the center of gravity is within the bounds of the selected surfaces
- **Positive Displacement:** Check for any surfaces with negative displacement. There are occasions when this is correct; for example a surface that is modeling a bow thruster tunnel. If any surfaces with negative displacement are found, the status will be shown as "See Details," and the surface(s) in question will be selected. You can click on the Details button for more information, or click the Flip button to flip the [normal direction](#)^[249].
- **Section Consistency:** If the surfaces that are selected for hydrostatics are not the same surfaces that were selected when the sections were defined, this check will fail

Add Objects: Clicking this button allows the addition of other surfaces or meshes to the selected set for analysis

Orca3D Units: To change any units except for the length unit (which is a Rhino unit and must be changed in the Rhino Properties dialog), click on the Orca3D Units button. The Orca3D Properties dialog is shown, with units information at the bottom. See [Properties and Units](#)⁷⁸ for more details.

10.6 Design Hydrostatics

Orca3D can compute hydrostatics and stability in various combinations of waterplanes/displacement and center of gravity/heel/trim, with a range of heel angles. However, while you are fairing a hull, you are usually just interested in the hydrostatics at the "design waterline," or at a particular displacement/center of gravity, and you don't want to have to open a dialog and enter values each time you repeat the calculation.

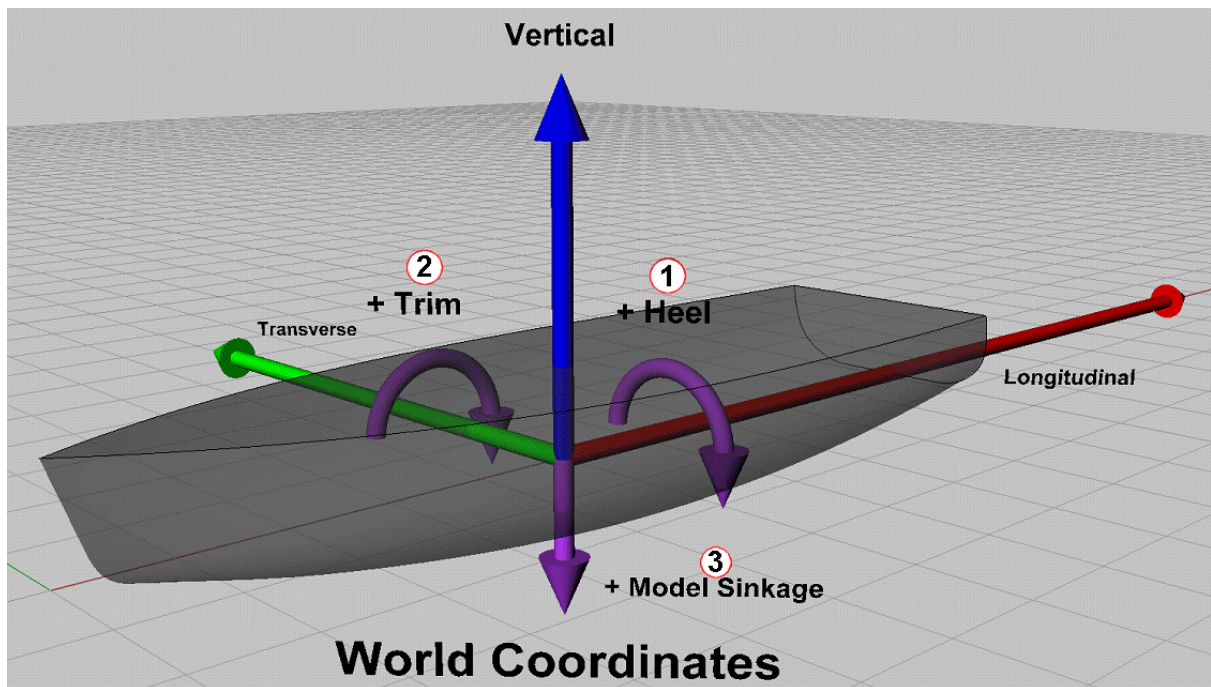
To simplify this process, Orca3D has a special Hydrostatics and Stability condition called the "Design" condition. The intent is to define the Design condition once, and then as you create and modify the hull, you can compute hydrostatics and stability at that condition with a single button click. This saves having to go through the dialog to define the condition each time you wish to compute the hydrostatics. Also, the Design Condition can be used as the condition to evaluate in Planing or Displacement resistance calculations.

Important; you will need to re-define your Design Condition when your hull model has fundamentally changed, e.g. you split, add, or delete a surface.

For complete information, please see the [Design Hydrostatics](#)¹³² topic in the Quick Start Tutorials section.

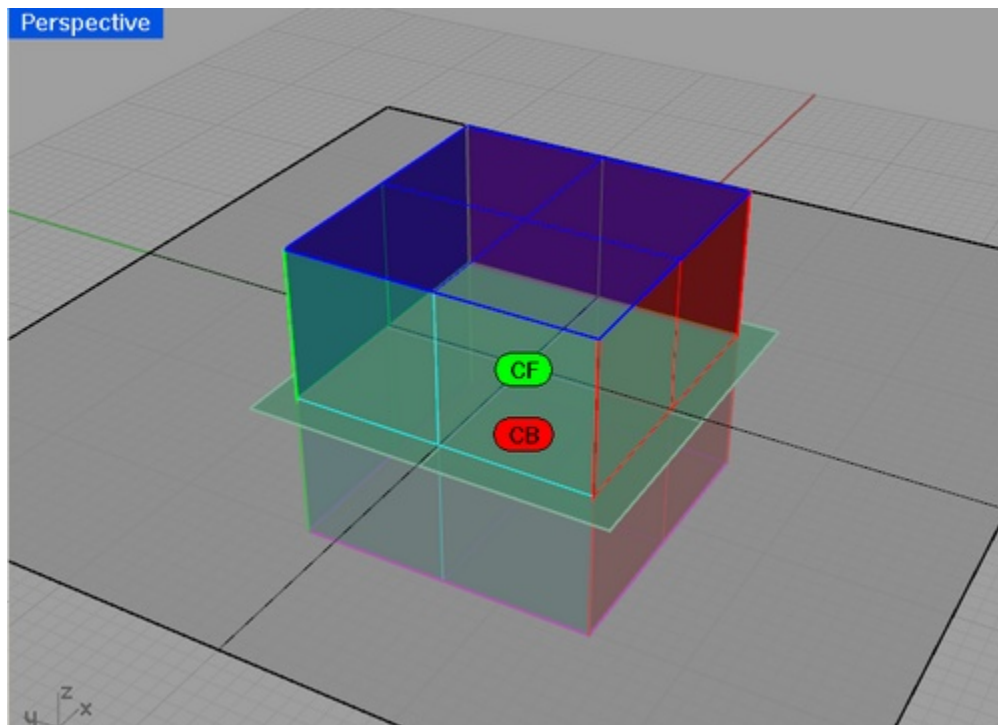
10.7 Output

Before the hydrostatic and stability calculations are performed, the model will be first be heeled about the world longitudinal axis (if necessary), then trimmed about the world transverse axis (if necessary), and finally sunk along the vertical world coordinate (if necessary) depending on the flotation condition(s) defined. For more detailed information on defining the flotation condition(s) see the [Defining the Flotation Condition\(s\)](#)²⁶¹ section. The results are reported in the coordinates of the boat in its orientation prior to the calculations. If you have chosen to transform the model to equilibrium flotation plane, the output results (such as VCB) are reported in the coordinate system of the original model orientation.

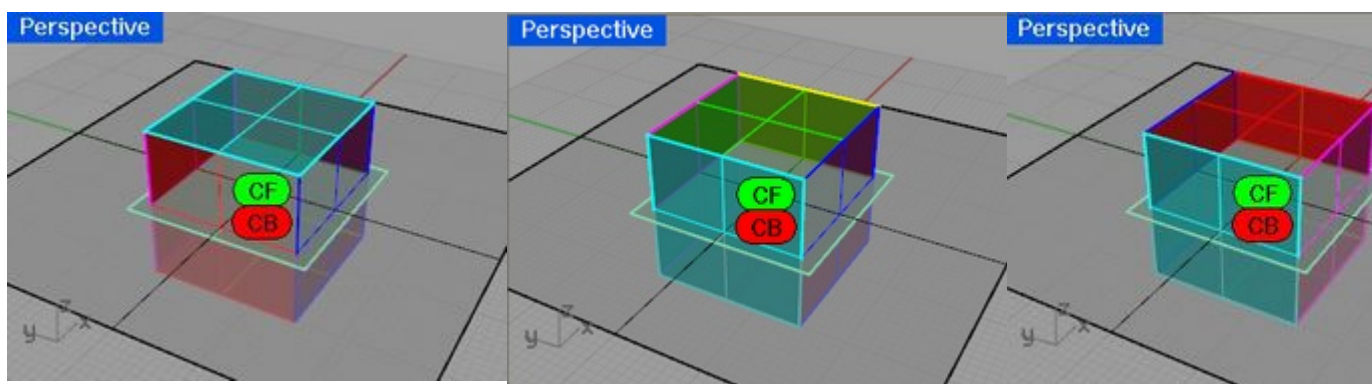


Equilibrium Condition

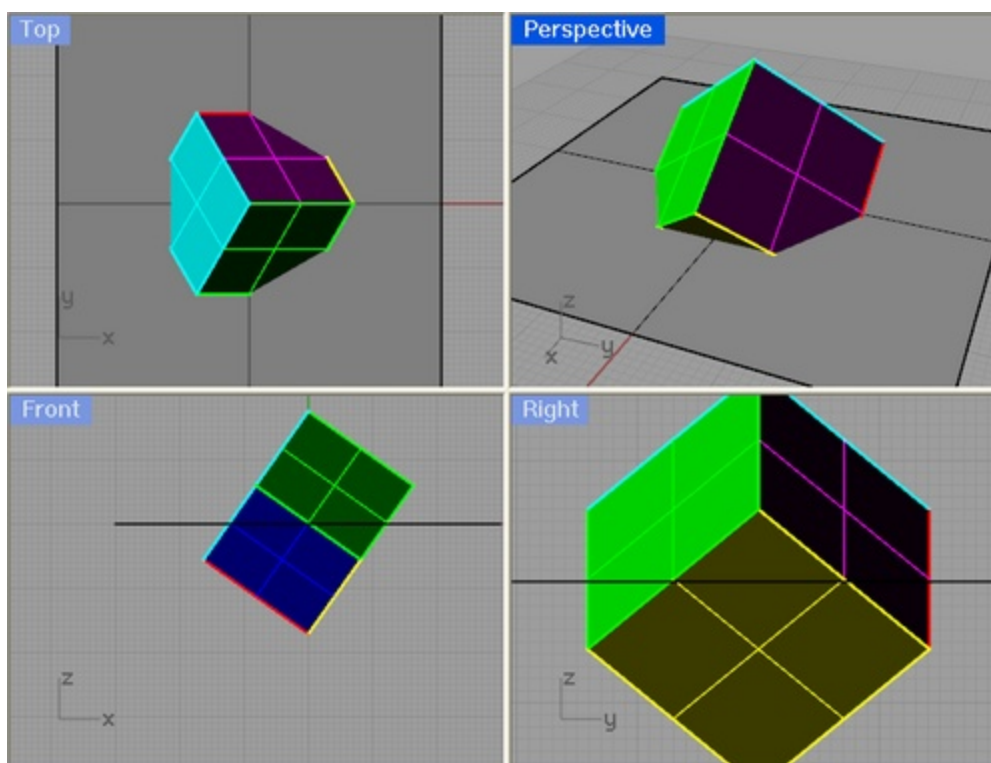
A vessel with a given shape and weight may have multiple orientations where it is in equilibrium. These equilibria may be stable or unstable, but they are all equilibrium conditions. For example, consider a cube, with half the density of water (so that it floats with half of its volume out of the water), and its center of gravity in the center of the cube. With an initial flotation plane at the midpoint, this equilibrium flotation plane will be found:



But of course, the cube is equally happy to float with any of the six sides up, each representing a valid equilibrium.

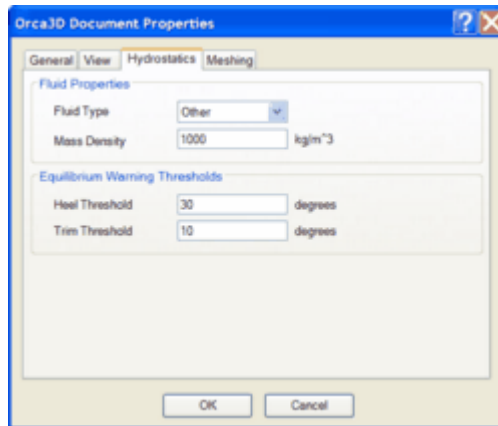


But none of these flotation conditions are actually stable. The center of buoyancy and center of gravity are aligned, but if the cube was disturbed, it would rotate to the following condition, which maximizes the waterplane inertia (and this orientation could be repeated with any of the 8 corners of the cube pointing up).



Orca3D will usually find the equilibrium condition that you expect, but sometimes, particularly when the equilibrium is far away from the initial condition (for example, a large off-center weight is applied that causes a large list angle), an unexpected condition will be found. The report will highlight values of Heel and Trim that are beyond the user-defined threshold values (set in [OrcaProperties](#) ⁷⁷), to make you aware of the situation. In the figures below,

the threshold value for trim has been set to 10 degrees, and the resultant condition had a trim slightly over 10 degrees. Also, the GMT and GMI were less than zero, so all three values are highlighted in the output.



Resulting Model Attitude and Hydrostatic Properties					
Condition	Sinkage (m)	Heel(deg)	Trim(deg)	Ax(m^2)	
Condition 1	0.000	11.054	-10.008	0.00	
Condition	Displacement (tonne-f)	LCB(m)	TCB(m)	VCB(m)	Wet Area (m^2)
Condition 1	4000.000	-0.869	-0.944	-4.833	1200.000
Condition	Awp(m^2)	LCF(m)	TCF(m)	VCF(m)	
Condition 1	400.000	0.000	0.000	0.000	
Condition	BMt(m)	BMI(m)	GMT(m)	GMI(m)	
Condition 1	3.333	3.333	-1.67	-1.67	

Another way to visualize the equilibrium condition is to [insert a plane](#)²⁶⁵ that represents the waterplane.

If you are having difficulty with Orca3D finding the "wrong" equilibrium condition, try the following:

- If the problem is occurring in the righting arm calculation, reduce the step size of the heel angles in the area of difficulty. For example, if you are computing every 10 degrees with 0,10,...,180, and the results look "wrong" after 50 degrees, use 0,10,...,45,50,...,180. You may find that you need to drop down to 1 degree increments in extreme cases.
- If the problem is in the initial flotation (e.g., a center of gravity that results in significant heel or trim), try rotating the model into an orientation that is closer to the final condition before starting. Or, it may be as simple as [overriding the initial flotation plane](#)²⁶⁵.

Output

The following are the calculated values provided in the hydrostatics and stability report and are provided for each flotation condition defined.

Load Condition Parameters

The following inputs define the flotation condition(s) by either weight or model sinkage, model trim or LCG, model heel or TCG, and VCG.

Weight: the overall weight of the model in the specified fluid density, in the units shown

Model Sinkage: the depth of the world origin below the resultant flotation plane, perpendicular to the resultant flotation plane. Positive sinkage is defined as the origin being below the flotation plane. This is sometimes referred to as "origin depth."

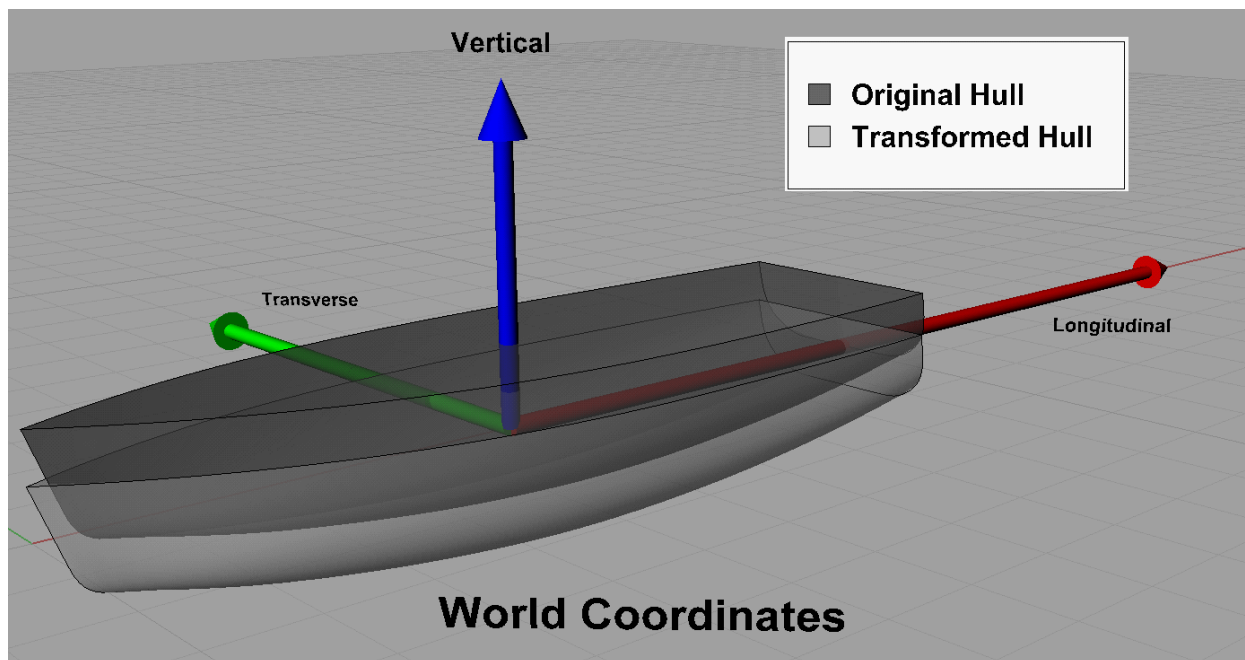


Figure 1.4 Model Positive Sinkage of 0.5 Meters

Model Trim: the trim angle of the vessel, in degrees from the horizontal plane in the world coordinates. A [right-hand coordinate system](#)²⁵⁹ is used, so that if positive X is aft, positive Y to starboard, and positive Z is up, a positive trim angle is bow up.

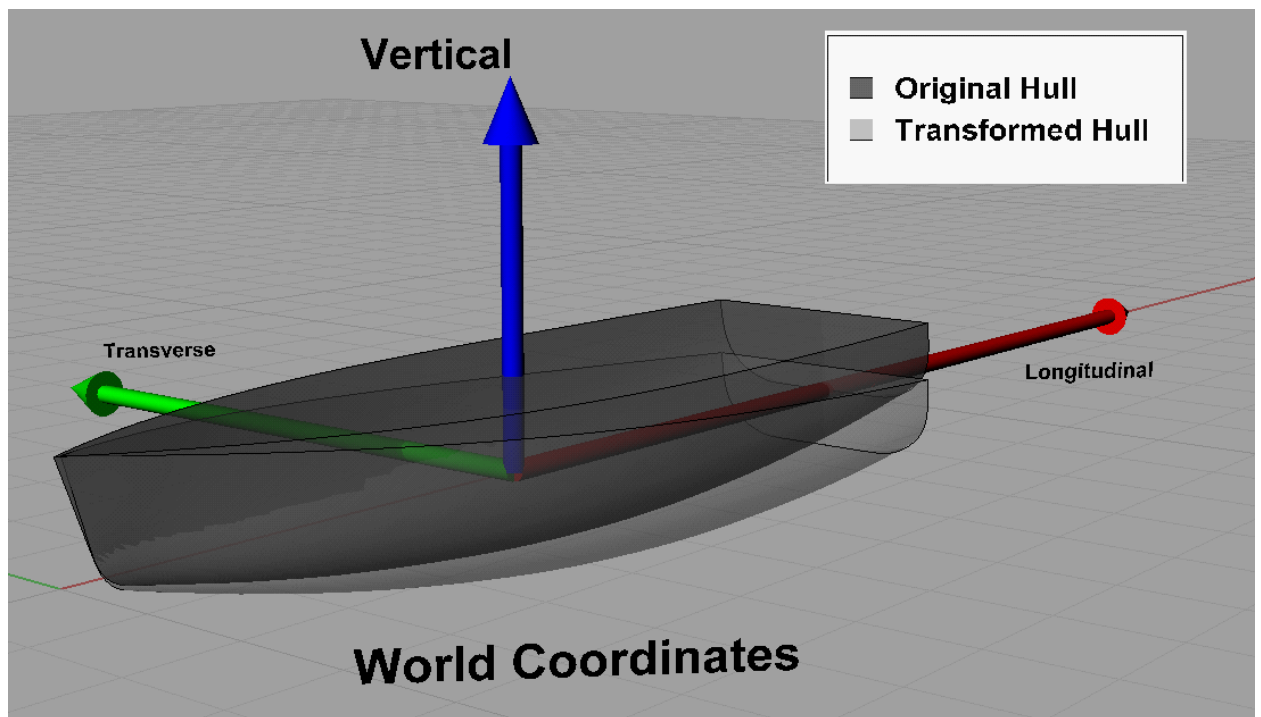


Figure 1.3 Model Trimmed Positive 3.5 Degrees

LCG: the longitudinal center of gravity of the vessel, in the units shown, measured from the world origin

Model Heel: the heel angle of the vessel, in degrees from the horizontal plane in the world coordinates. A [right-hand coordinate system](#)²⁵⁹ is used, so that if positive X is aft, positive Y to starboard, and positive Z is up, a positive heel angle is to port.

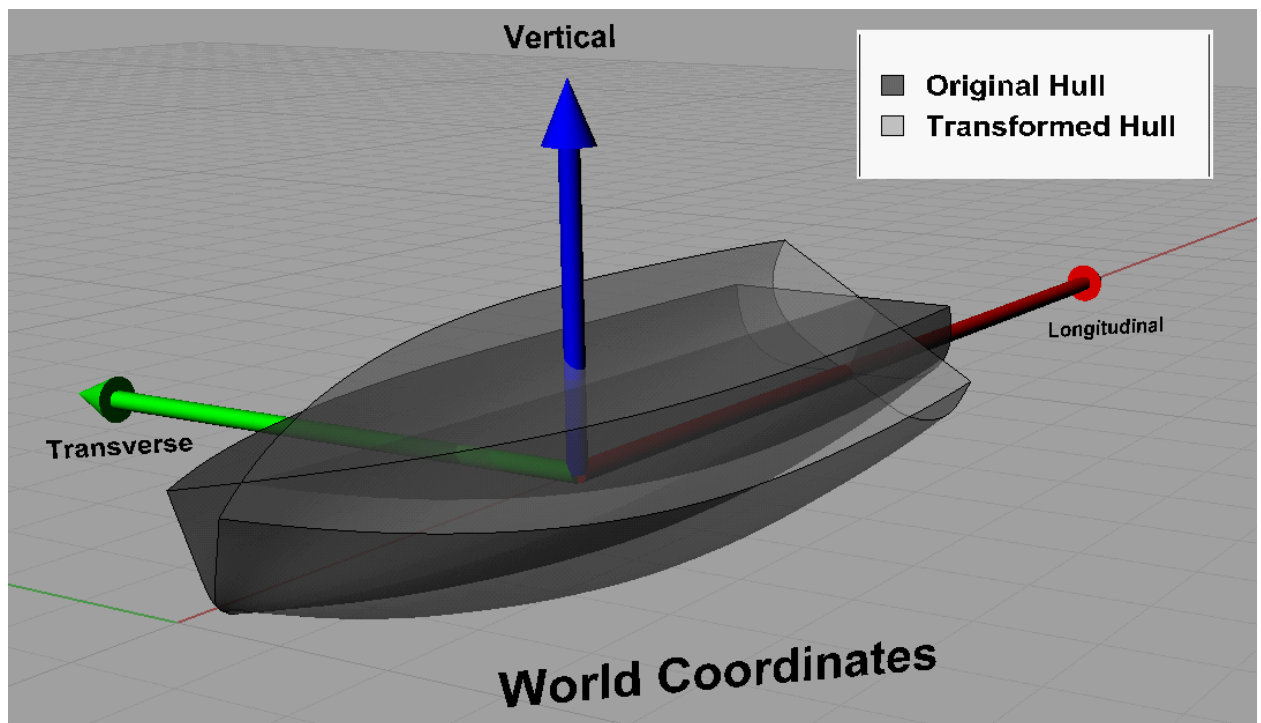


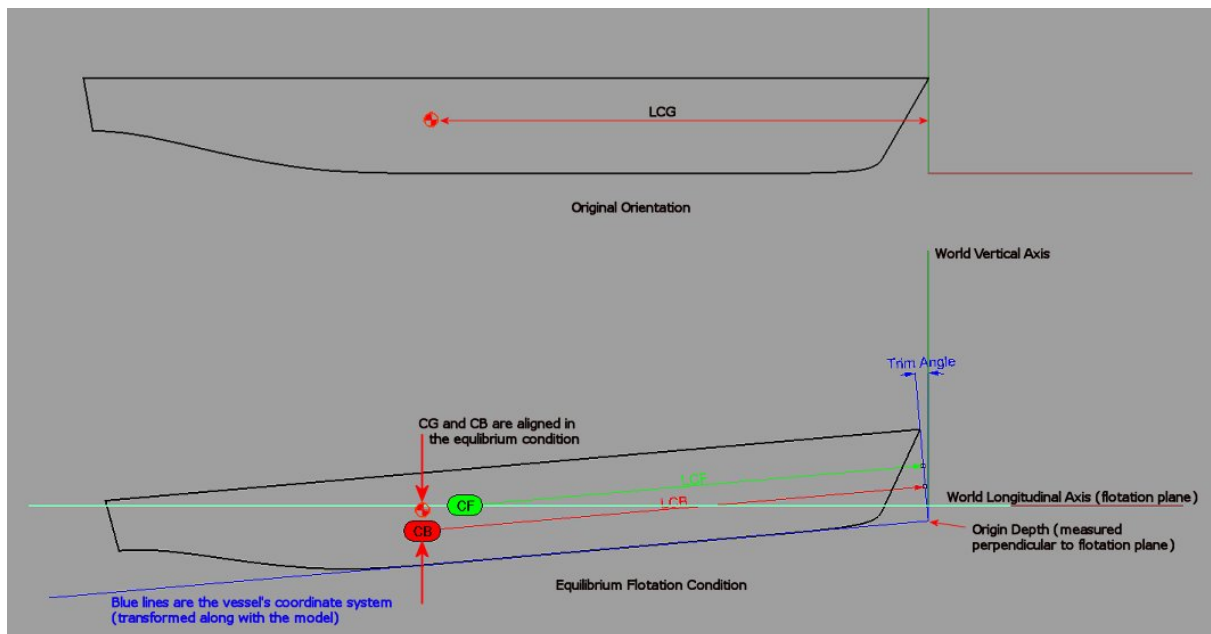
Figure 1.2 Model Heeled Positive 30 Degrees

TCG: the transverse center of gravity of the vessel, in the units shown measured in the transverse axis from the world origin

VCG: the vertical center of gravity of the vessel, in the units shown measured in the vertical axis from the Rhino origin

Resulting Model Attitude and Hydrostatic Properties

The resulting model orientation and calculated hydrostatic properties for each defined flotation condition(s). All values include only those surfaces that were selected for the computation. Note that even if you have not chosen the option to "Transform the model to the resultant flotation plane," results are reported as if the model moved in the Rhino coordinate system, such that the plane of the Rhino origin (e.g. $Z=0$) is the flotation plane. Coordinates are reported in the "vessel's coordinate system." The vessel's coordinates are created by transforming the original coordinate system along with the model (heel, trim, and sinkage). In the figure below, The center of buoyancy (CB) and center of flotation (CF) are shown, with their location in the vessel's coordinates.



Condition Summary

A summary of the values used to define the condition are shown (for example, the values of Sinkage, Trim, and Heel that were entered).

Surface Meshing Parameters

These are the values of the mesh settings for the model. For a description of how they affect the results, see the [Mesh Parameters](#) ⁸⁸ section of [Properties & Units](#) ⁷⁷.

Load Condition Parameters

The load condition parameters and resultant model attitude are shown again for the load condition. Also, the fluid type and fluid density are displayed in the units shown, together with an indicator to show if the geometry was mirrored for the computations.

Resultant Model Attitude

Heel Angle: the resultant heel angle, in degrees, of the vessel from the horizontal plane in the world coordinates resulting from the defined flotation condition.

Trim Angle: the resultant trim angle, in degrees, of the vessel from the horizontal plane in the world coordinates resulting from the defined flotation condition.

Sinkage: the depth of the world origin below the resultant flotation plane, perpendicular to the resultant flotation plane. Positive sinkage is defined as the origin being below the flotation plane. This is sometimes referred to as "origin depth."

Overall Dimensions

Length Overall, LOA: The length of the vessel, including portions that are not submerged

Beam Overall, BOA: The maximum beam of the vessel, including portions that are not submerged. (If the model is a multihull, this dimension is the maximum from the outermost point on one side of the vessel to the outermost point on the opposite side. It does not refer to a single hull.)

Depth Overall, D: The maximum depth of the vessel, from the deepest point in the water to the highest point above the water.

Loa/Boa: The ratio of the Length Overall to the Beam Overall

Boa/D: The ratio of the Beam Overall to the Depth Overall

Waterline Dimensions

Waterline length, Lwl: The waterline length of the vessel

Waterline Beam, Bwl: The waterline beam of the vessel. (If the model is a multihull, this dimension is the maximum from the outermost point on the waterline on one side of the vessel to the outermost point on the waterline on the opposite side. It does not refer to the waterline beam of a single hull.)

Navigational Draft, T: The distance, perpendicular to the flotation plane, from the flotation plane down to the deepest point on the model. If the model has appendages (such as a sailboat keel), they will be included.

Lwl/Bwl: The ratio of the Waterline Length to the Waterline Beam.

Bwl/T: The ratio of the Waterline Beam to the Navigational Draft.

D/T: The ratio of the Depth Overall to the Navigational Draft

Volumetric Values

Displacement: the overall weight of the vessel, in the units shown, as defined in the input or calculated from the defined flotation condition.

Volume: The integrated underwater volume of the vessel in the units shown.

LCB: the longitudinal center of buoyancy of the resultant model orientation in the units shown, reported in the vessel's coordinates.

TCB: the transverse center of buoyancy of the resultant model orientation in the units shown, reported in the vessel's coordinates.

VCB: the vertical center of buoyancy of the resultant model orientation in the units shown, reported in the vessel's coordinates.

Wet Area: the area, in the units shown, of the underwater surfaces selected for the hydrostatic & stability analysis.

Moment to Trim: the longitudinal moment required to trim the vessel, in the units shown. For example, a trim of 1 cm means that the vessel has trimmed enough to create a change in draft of 1 cm between the fore and aft ends of the waterline.

Displ-Length Ratio: The displacement length ratio, which is always expressed in imperial units of long tons/ft³. It is defined as (Displacement in long tons / (Length in feet/100)³)

FB/Lwl: The ratio of LCB to LWL, measured from the forward end of LWL; a value less than 0.5 means that the LCB is forward of the midpoint of LWL.

TCB/Bwl: The ratio of the transverse center of buoyancy to the waterline beam.

S: Wetted Area is labeled "S" in the Area Properties graph

Waterplane Values

Awp: the area, in the units shown, of the waterplane of the resultant model orientation.

LCF: the longitudinal center of flotation of the resultant model orientation in the units shown, reported in the vessel's coordinates.

TCF: the transverse center of flotation of the resultant model orientation in the units shown, reported in the vessel's coordinates.

Weight to Immerse: the weight required to sink the vessel one unit in the direction perpendicular to the equilibrium flotation plane.

FF/Lwl: The ratio of LCF to LWL, measured from the forward end of LWL; a value less than 0.5 means that the LCF is forward of the midpoint of LWL.

TCF/Bwl: The ratio of the transverse center of flotation to the waterline beam.

Sectional Parameters

Ax: the maximum underwater sectional area calculated using Orca sections, in the units shown. The maximum value is interpolated from the Orca sections, by fitting a parabola to the Orca station of maximum sectional area and the two stations on either side of it. If no Orca sections are specified, this value will be 0.

Ax Location: The longitudinal location, in Rhino coordinates, of the station of maximum area (see note on interpolation above)

Ax Location / Lwl: The ratio of Ax Location to LWL, measured from the forward end of LWL; a value less than 0.5 means that the Ax is forward of the midpoint of LWL.

Hull Form Coefficients

Cb: the block coefficient of the resultant model orientation due to the defined flotation condition, defined as $(\text{displaced volume} / (\text{LWL} \times \text{BWL} \times T))$, where T is the maximum navigational draft (i.e. the lowest point on the model in the resultant model orientation, which could include objects such as a keel).

Cp: the prismatic coefficient of the resultant model orientation, defined as $(\text{displaced volume} / (\text{LWL} \times A_x))$, where A_x is the maximum sectional area. If no Orca sections are defined, this will be 0.

Cvp: the vertical prismatic coefficient of the resultant model orientation, defined as $(\text{displaced volume} / (\text{AWP} \times T))$, where T is the maximum navigational draft (i.e. the lowest point on the model in the resultant model orientation, which could include objects such as a keel).

Cx: the maximum section coefficient of the resultant model orientation, defined as $(A_x / (\text{BWL} \times T))$, where T is the maximum navigational draft (i.e. the lowest point on the model in the resultant model orientation, which could include objects such as a keel). If no Orca sections are defined, this will be 0.

Cwp: the waterplane coefficient of the resultant model orientation, defined as $(\text{AWP} / (\text{LWL} \times \text{BWL}))$.

Cws: the wetted surface coefficient of the resultant model orientation, defined as $(\text{wetted surface} / \text{SQRT}(\text{displaced volume} \times \text{LWL}))$.

Static Stability Parameters

Note that the 0 degree condition is taken as the original model orientation, not the equilibrium flotation plane. If a non-zero TCG or a non-zero Model Heel are entered, there will be a non-zero righting arm at 0 degrees of heel. Zero righting arm will correspond to the heel angle at the equilibrium flotation plane.

The calculation of the righting arm allows the model to trim as it heels to maintain a true hydrostatic balance (this is true even if a Model Trim was entered to define the equilibrium flotation plane; the Model Trim is used to determine the center of gravity, which is then used as the model is heeled).

I (transverse): The transverse moment of inertia of the waterplane

I (longitudinal): The longitudinal moment of inertia of the waterplane

BMt: the transverse metacentric radius (distance from the vertical center of buoyancy to the transverse metacenter) of the resultant flotation condition

BMI: the longitudinal metacentric radius (distance from the vertical center of buoyancy to the longitudinal metacenter) of the resultant flotation condition

GMt: the transverse metacentric height (distance from the vertical center of gravity to the transverse metacenter) of the resultant flotation condition

GMI: the longitudinal metacentric height (distance from the vertical center of gravity to the longitudinal metacenter) of the resultant flotation condition

Mt: the height of the transverse metacenter in the resultant flotation condition, measured from the equilibrium flotation plane

MI: the height of the longitudinal metacenter in the resultant flotation condition, measured from the equilibrium flotation plane

Station Data

If [Orca stations](#)²³⁶ are defined, a plot of the immersed area and wetted girth versus station location is displayed. A table of station location, measured from the Rhino origin, immersed area and wetted girth is shown.

Stability Curve

If the “Compute Righting Arm at these Heel Angles” box is checked in the [Hydrostatics & Stability Analysis dialog](#)²⁶¹, a stability curve will be plotted for righting arm versus heel angle. A table of trim angle, righting arm and righting moment, in the units shown, is displayed for each defined heel angle. Note that the 0 degree condition is taken as the original model orientation, not the equilibrium flotation plane. If a non-zero TCG or a non-zero Model Heel are entered, there will be a non-zero righting arm at 0 degrees of heel. Zero righting arm will correspond to the heel angle at the equilibrium flotation plane.

Points of Interest

If any [Points of Interest](#)¹⁴⁴ have been defined, a table defining their locations will be shown, followed by a table showing their heights above (+) or below (-) the flotation plane at each heel angle.

10.8 Scripting Hydrostatics

Hydrostatics Command Scripting Reference

Orca3D's hydrostatics command can be scripted using Rhino's command scripting, and also using RhinoScript. Below the syntax of the command scripting is given, followed by an example macro to compute vessel hydrostatics and write the output to a CSV file. Also below is a slightly more complex RhinoScript that uses the OrcaHydrostatics command to compute and report the hydrostatics of a hull that is created with a hull wizard.

Command Name: OrcaHydrostatics

Notes:

1. Must pre-select or post-select one or more surface/polysurface/mesh objects
2. Lists of values use standard Orca3D list syntax; e.g. 0,10,...,180
3. The decimal separator must be a dot "." and the list separator must be the comma ","

Command Options:

Description – a string description of the hydrostatics analysis

LoadCases – define the loading condition options for the hydrostatics analysis

SinkageOptions – define the sinkage options for the hydrostatics analysis

SpecifySinkage – a list of sinkage values for the analysis; a loading condition and subsequent hydrostatics computation will be performed for each sinkage value listed

SpecifyWeight – a list of weight values for the analysis; a loading condition and subsequent hydrostatics computation will be performed for each weight value listed

TrimOptions – define the trim options for the hydrostatics analysis

SpecifyTrim – a list of trim values for the analysis; a loading condition and subsequent hydrostatics computation will be performed for each trim value listed

SpecifyLCG – a list of LCG values for the analysis; a loading condition and subsequent hydrostatics computation will be performed for each LCG value listed

HeelOptions – define the heel options for the hydrostatics analysis

SpecifyHeel – a list of heel values for the analysis; a loading condition and subsequent hydrostatics computation will be performed for each heel value listed

SpecifyTCG – a list of TCG values for the analysis; a loading condition and subsequent hydrostatics computation will be performed for each TCG value listed

VCG – a list of vertical VCG coordinate values for the analysis; a loading condition and subsequent hydrostatics computation will be performed for each VCG value listed; VCG values are optional for analyses where a fixed trim angle or heel angle is specified; if entered in these optional cases, they will be used to compute GM

Mirror – Yes if the selected geometry must be mirrored about the centerplane for the hydrostatics analysis

TransformModel – Yes if the selected geometry is to be transformed to the resultant flotation plane; otherwise No (this option cannot be Yes if AddPlane=Yes)

AddPlane – Yes if a plane surface should be added for each loading condition; otherwise No (this option cannot be Yes if TransformModel=Yes)

InitialHeight – a floating point value defining the vertical coordinate at which to start the flotation plane iteration; this value is only meaningful for free float computations

RightingArms – define the righting arm options for the hydrostatics analysis

Compute – Yes to compute righting arm(s) at specified heel angle(s); otherwise No

HeelAngles – a sorted list of comma-separated heel angles at which to compute righting arms

WriteToCSV - Yes to export a comma-separated-value (CSV) file containing the output from the hydrostatics calculation

Enter CSV filename <Hydrostatics.csv>

ShowReport - Yes to show the hydrostatics output in the Microsoft ReportViewer

Sample Macro: (note that copying and pasting this sample into Rhino may not work, since some characters may not be correctly copied)

-_New n

```
-_DocumentProperties u u e n enter enter
-_OrcaCreateSailboat LengthOnDeck 10 BeamOnDeck 3 TransomBeamRatio 0.9
StemDeckHeight 1 TransomDeckHeight 0.9 TransomHeight 0 Draft 0.5 StemRake 20
TransomRake 10 SheerHeightRatio 0.9 SheerHeightPos 0.5 DeckBeamPos 0.5 DraftPos
0.5 SectionFullnessFactor 0 BilgeTurnFactor 0.5 ForefootShape 0.5 NumberRows 6
NumberCols 7 enter
-_SelAll
-_OrcaHydrostatics Mirror=Yes Description "Sample Sailboat Hydrostatics Macro"
WriteToCSV=Yes "hydrostatics.csv" enter
```

Below is a sample RhinoScript demonstrating the use of the OrcaHydrostatics command. The Orca3D plug-in object exposes the most recently computed hydrostatics results through the property, "MostRecentStabilityResults." As seen in the script below, this property represents an array of hydrostatics objects that contains the most recent upright hydrostatics together with any associated rollover hydrostatics, if computed. Following the script below is a table that lists the properties that the Orca3D hydrostatics object exposes to scripters.

Sample Script: (note that copying and pasting this sample into Rhino may not work, since some characters may not be correctly copied; a copy is located in the Sample Data subfolder of the Orca3D installation folder (normally C:\Program Files\Orca3D\Sample Data)

```
Option Explicit
'Script written by <insert name>
'Script copyrighted by <insert company name>
'Script version Monday, October 3, 2016 2:37:09 PM

Call Main()

Sub Main()

' -----
'
'   Sample script demonstrating Orca3D hydrostatics
'   Created By: Larry Leibman
'   Date: 5/31/2011
'   Revision: 1.3 10/3/2016
'
' -----

' Start a new model, Set document properties, create a sailboat hull

Rhino.Command "-_New n"

Rhino.Command "-_DocumentProperties u u e n enter enter"

Rhino.Command "-_OrcaCreateSailboat LengthOnDeck 10 BeamOnDeck 3
TransomBeamRatio 0.9 StemDeckHeight 1 TransomDeckHeight 0.9 TransomHeight
0" + _
    " Draft 0.5 StemRake 20 TransomRake 10 SheerHeightRatio 0.9
SheerHeightPos 0.5 DeckBeamPos 0.5 DraftPos 0.5" + _
    " Deadrise 0 Flare 0 SectionTightness 0.5 ForefootShape 0.5
```

```
NumberRows 6 NumberCols 7 enter"
```

```
' Select model geometry
```

```
Call SelectModelGeometry
```

```
' Create sections
```

```
Rhino.Command "-_OrcaSections Stations Add 0,.5,...,10.5 enter enter  
enter"
```

```
' Re-Select all surface, polysurface And mesh objects
```

```
Call SelectModelGeometry
```

```
' Compute hydrostatics
```

```
Rhino.Command "-_OrcaHydrostatics Mirror=Yes Description ""Sample  
Hydrostatics Upright"" " + _  
"LoadCase SinkageOptions SpecifySinkage 0.15 TrimOptions  
SpecifyTrim 0 HeelOptions SpecifyHeel 0 VCG 0" + _  
" enter RightingArms Compute=No HeelAngles 0,10,...,180 enter  
enter"
```

```
' Rhino.Command "-_OrcaHydrostatics Description ""Sample Hydrostatics  
Free-Float with Righting Arms"" " + _  
' "LoadCases SinkageOptions SpecifyWeight 6400  
TrimOptions SpecifyLCG 5 HeelOptions SpecifyTCG 0 VCG 0 enter " + _  
' "RightingArms Compute=Yes HeelAngles 0,5,...,180 enter  
Mirror=Yes TransformModel=No AddPlane=Yes InitialHeight=0.25 enter"
```

```
' Rhino.Command "-_OrcaHydrostatics Description ""Initial  
Hydrostatics"" LoadCases SinkageOptions SpecifyWeight 6400" + _  
' " TrimOptions SpecifyLCG 5 HeelOptions SpecifyTCG 0  
VCG 0 enter RightingArms Compute=No HeelAngles 0,5,...,180" + _  
' " enter Mirror=Yes TransformModel=No AddPlane=No  
InitialHeight=0.25 enter"
```

```
' Retrieve
```

```
On Error Resume Next
```

```
Dim orcaPlugIn
```

```
Set orcaPlugIn = Rhino.GetPluginObject("Orca3D")
```

```
Dim hydrostaticsList
```

```
If Not IsNull(orcaPlugIn) Then
```

```
    hydrostaticsList = orcaPlugIn.MostRecentStabilityResults
```

```
End If
```



```

' Print hydrostatics

Dim output,i
Dim hydrostatics, hydrostaticsArray

output = ""
If hydrostaticsList <> Nothing And IsArray(hydrostaticsList) Then
    For Each hydrostatics In hydrostaticsList
        output = output & VbCrLf + VbCrLf +
HydrostaticsString(hydrostatics)
    Next
End If

Rhino.TextOut output

End Sub

' -----
--
' Subroutine to select all surfaces, polysurfaces, and meshes in the model
' -----
--

Sub SelectModelGeometry()
    ' Select all surface, polysurface And mesh objects
    Rhino.Command "-_SelSrf"
    Rhino.Command "-_SelPolySrf"
    Rhino.Command "-_SelMesh"
End Sub

' -----
--
' Function to retrieve a string representation of hydrostatics results.
' -----
--

Function HydrostaticsString(hydrostatics)

    HydrostaticsString = CStr(hydrostatics.AnalysisDescription) + VbCrLf
+   -
        CStr(hydrostatics.When) + VbCrLf + _
        "Lwl = " + CStr(hydrostatics.LWL) + VbCrLf + _
        "Bwl = " + CStr(hydrostatics.BWL) + VbCrLf + _
        "Draft = " + CStr(hydrostatics.Draft) + VbCrLf + _
        "Loa = " + CStr(hydrostatics.Loa) + VbCrLf + _
        "Boa = " + CStr(hydrostatics.Boa) + VbCrLf + _
        "Depth = " + CStr(hydrostatics.Depth) + VbCrLf + _
        "LCB = " + CStr(hydrostatics.LCB) + VbCrLf + _
        "TCB = " + CStr(hydrostatics.TCB) + VbCrLf + _
        "VCB = " + CStr(hydrostatics.VCB) + VbCrLf + _
        "LCF = " + CStr(hydrostatics.LCF) + VbCrLf + _
        "TCF = " + CStr(hydrostatics.TCF) + VbCrLf + _
        "VCF = " + CStr(hydrostatics.VCF) + VbCrLf + _
        "Displacement = " + CStr(hydrostatics.Displacement) + VbCrLf +

```

```

-
    "Volume = " + CStr(hydrostatics.Volume) + VbCrLf + _
    "Wet Area = " + CStr(hydrostatics.WetArea) + VbCrLf + _
    "Sinkage = " + CStr(hydrostatics.Sinkage) + VbCrLf + _
    "Trim = " + CStr(hydrostatics.Trim) + VbCrLf + _
    "List = " + CStr(hydrostatics.List) + VbCrLf + _
    "Cb = " + CStr(hydrostatics.Cb) + VbCrLf + _
    "Cx = " + CStr(hydrostatics.Cx) + VbCrLf + _
    "Cp = " + CStr(hydrostatics.Cp) + VbCrLf + _
    "Cvp = " + CStr(hydrostatics.Cvp) + VbCrLf + _
    "Cwp = " + CStr(hydrostatics.Cwp) + VbCrLf + _
    "Cws = " + CStr(hydrostatics.Cws)

```

End Function

Below is a table of the variables that are available for scripting. Note that they are case sensitive. When defining limits for stability criteria, only the variables which are of type Double may be used.

Property	Description	Type
ResultType	The hydrostatics result type.	StabilityResultType 0 = Unknown 1 = FixedFlotationPlane 2 = FreeFloatEquilibrium 3 = Rollover
HydrostaticsID	The ID of the hydrostatics (a guid string).	string
HydrostaticsBaseID	The ID of the base hydrostatics (GUID string) to which this hydrostatics refers	string
AnalysisDescription	A description of the hydrostatics analysis	string
ConditionName	Name of the condition	string
CompanyName	Company name	string
ProjectTitle	Project title	String
<u>LengthUnitSymbol</u>	Length unit symbol	<u>string</u>
AreaUnitSymbol	Area unit symbol	string
VolumeUnitSymbol	Volume unit symbol	string
InertiaUnitSymbol	Inertial unit symbol	string
WeightUnitSymbol	Weight unit symbol	string
WeightToImmerseUnitSymbol	Weight to immerse unit symbol	string
MomentUnitSymbol	Moment unit symbol	string
MomentToTrimUnitSymbol	Moment to change trim unit symbol	string

PlaneAngleUnitSymbol	Plane angle unit symbol	string
MassDensityUnitSymbol	Mass density unit symbol	string
DisplacerFluidType	String representation of the fluid type	string
FluidDensity	Fluid density for the hydrostatics calculation	double
CenterOfBuoyancy	The most recently computed center of buoyancy location in body coordinates.	IPoint3d containing members X, Y, Z each of type double
CenterOfFlotation	The most recently computed center of flotation in body coordinates.	IPoint3d containing members X, Y, Z each of type double
Displacement	The most recently computed displacement value.	double
Placement	The current body coordinate axis2placement for the analysis mesh geometry. The orientation for this axis2placement is aft, starboard, up (not Rhino orientations). This is because there is need to know the transformation of the waterplane relative to body orientation separate from the global body orientation relative to rhino orientation.	IAxis2Placement containing members Origin, XAxis, YAxis, each of which contains members X, Y, Z, each of type double
VCG	String representation of the VCG in body coordinates (string used in case no VCG is available)	string
TransverseGM	String representation of the transverse GM (string used in case no GMt is available)	string
LongitudinalGM	String representation of longitudinal GM (string used in case no GMl is available)	string
TransverseMetacenter	Height of the transverse metacenter (measured from waterplane)	double
LongitudinalMetacenter	Height of the longitudinal metacenter (measured from waterplane)	double
MomentToTrim	Moment to change trim	double
WeightToImmerse	Weight to immerse	double
HeaveBoundaryConditionValue	Heave boundary condition value for hydrostatics calculation	double

HeaveBoundaryConditionName	Heave boundary condition name for hydrostatics calculation	string
HeaveBoundaryConditionUnit	Heave boundary condition units for hydrostatics calculation	string
ListBoundaryConditionValue	List boundary condition value for hydrostatics calculation	double
ListBoundaryConditionName	List boundary condition name for hydrostatics calculation	string
ListBoundaryConditionUnit	List boundary condition units for hydrostatics calculation	string
TrimBoundaryConditionValue	Trim boundary condition value for hydrostatics calculation	double
TrimBoundaryConditionName	Trim boundary condition name for hydrostatics calculation	string
TrimBoundaryConditionUnit	Trim boundary condition units for hydrostatics calculation	string
WaterplaneArea	The most recently computed waterplane area.	double
WaterplaneInertia	The most recently computed waterplane inertia value.	IPoint3d containing members X, Y, Z each of type double
WetArea	The most recently computed wetted surface area.	double
LCB	The most recently computed longitudinal center of buoyancy in body coordinates.	double
TCB	The most recently computed transverse center of buoyancy in body coordinates.	double
VCB	The most recently computed vertical center of buoyancy in body coordinates.	double
It	The most recently computed transverse waterplane inertia.	double
Il	The most recently computed longitudinal waterplane inertia.	double
BMt	The most recently computed transverse BM.	double
BMl	The most recently computed longitudinal BM.	double

List	The heel angle associated with the resultant free float condition in user units. This is defined as the angle between the body's transverse axis and the resultant flotation plane as per GHS. Its sign uses the Rhino positive sense based on the Rhino longitudinal axis	double
Trim	The trim angle associated with the resultant free float condition in user units. This is defined as the angle between the body's long'l axis and the resultant flotation plane as per GHS. Its sign uses the Rhino positive sense based on the Rhino transverse axis	double
Sinkage	Sinkage associated with the resultant free float condition at the origin.	double
Loa	The most recently computed overall length.	double
Boa	The most recently computed overall beam.	double
Depth	The most recently computed depth.	double
Lwl	The most recently computed waterline length.	double
Bwl	The most recently computed waterline beam.	double
Draft	The most recently computed draft.	double
Volume	The most recently computed volume.	double
LCF	The most recently computed longitudinal center of flotation in body coordinates.	double
TCF	The most recently computed transverse center of flotation in body coordinates.	double
VCF	The most recently computed vertical center of flotation in body coordinates.	double
Ax	The most recently computed maximum section area.	double
XAx	The most recently computed location of station of max section area.	double

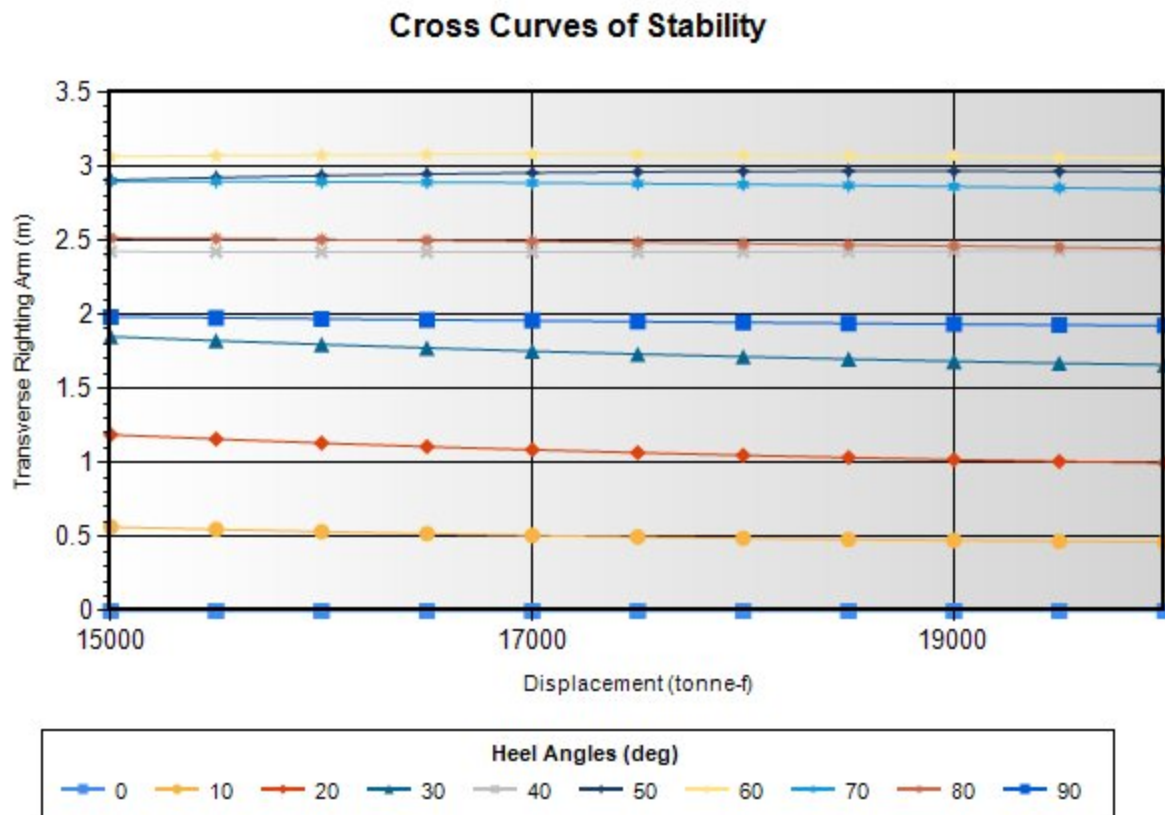
When	The date and time when this hydrostatics object was created.	DateTime
TransverseRightingArm	Most recently computed transverse righting arm.	double
TransverseRightingMoment	The most recently computed transverse righting moment.	double
Cb	Block coefficient	double
Cwp	Waterplane coefficient	double
Cws	Wetted surface coefficient	double
Cp	Longitudinal prismatic coefficient	double
Cvp	Vertical prismatic coefficient	double
Cx	Maximum section coefficient	double
DLRatio	Displacement-length ratio; it is dimensional and in English units of long tons / ft^3	double
LCB_Lwl	Non-dimensional ratio LCB/Lwl measured from fwd end of waterline.	double
LCF_Lwl	Non-dimensional LCF/Lwl measured from fwd end of waterline.	double
ResultTypeString	String description of result type.	string
MirrorGeometry	Whether or not geometry was mirrored	bool
MeshDensity	Hydrostatics mesh density for calculation mesh // so that it doesn't show up in real-time values list	double
MeshMaxAngle	Hydrostatics mesh maximum angle for calculation mesh // so that it doesn't show up in real-time values list	double
MeshMaxAspectRatio	Hydrostatics mesh maximum aspect ratio for calculation mesh // so that it doesn't show up in real-time values list	double
MeshMinEdgeLength	Hydrostatics Mesh minimum edge length for calculation mesh // so that it doesn't show up in real-time values list	double
MeshMaxEdgeLength	Hydrostatics mesh maximum edge length for calculation mesh // so that it doesn't show up in real-time values list	double

MeshMaxDistance	Hydrostatics mesh maximum distance for calculation mesh // so that it doesn't show up in real-time values list	double
MeshMinQuads	Hydrostatics mesh minimum quads for calculation mesh	int
MeshRefine	Hydrostatics mesh refinement flag for calculation mesh	bool
MeshJaggedSeams	Hydrostatics mesh jagged seams flag for calculation mesh	bool
MeshSimplePlanes	Hydrostatics mesh simple planes flag for calculation mesh	bool

10.9 Cross Curves of Stability

Toolbar	<i>n/a</i>
Menu	Orca3D > Stability > Compute Cross Curves of Stability
Command	OrcaCrossCurves

This function allows you to compute the traditional cross curves of stability; that is, the transverse righting arm versus displacement for a range of heel angles.



The results of the computation are reported graphically in the standard output report for hydrostatics, with the addition of the Cross Curves plot at the end of the Curves of Form plots. Each condition analyzed to create the Cross Curves is included in the report. as with Hydrostatics calculations, the data may also be saved to a .csv file (easily read into Excel), if numeric data is required or you wish to create your own plots.

To compute cross curves of stability, select "Compute Cross Curves of Stability" from the Orca3D > Stability menu, or type OrcaCrossCurves in the Rhino command line. The input dialog will be shown:

Displacement Range: Use this field to enter the range of displacements, either by specifying the actual displacements, or indirectly by specifying Sinkage (relative to the model's current location in the Rhino World Coordinate System). You may enter a comma-separated list, and make use of the ellipsis shorthand (for example, 1,2,...,5,7,...,15 means to start at 1, increment by 1 until 5, and then increment by 2 until 15). Pay attention to the units (e.g., kg, tonnes, mm, etc.). Length units are changed in the Rhino Properties dialog, and other units are changed in the [Orca3D Properties](#) dialog.

Trim Options: The model is free to trim as it rolls. The value entered here simply establishes the initial LCG, either by direct input of LCG or indirectly by input of the trim angle. This is then used together with displacement/sinkage and heel/TCG to establish the initial flotation plane. If Trim is selected, that trim will be used at each displacement/sinkage to determine an LCG, which means that, for non-trivial shapes, the LCG will vary with displacement/sinkage. The LCG that is determined is then held constant as the model rolls over (free to trim). If LCG is specified, the same LCG is used at each displacement/sinkage for the roll over calculations.

Heel Options: The value entered here simply establishes the initial TCG, either by direct input of TCG or indirectly by input of the heel angle. This is then used together with displacement/sinkage and Trim/LCG to establish the initial flotation plane. If Heel is selected, that heel will be used at each displacement/sinkage to determine the TCG, which

means that, for non-trivial shapes, the TCG will vary with displacement/sinkage. If TCG is specified, the same TCG is used at each displacement/sinkage for the roll over calculations.

VCG (or pole height): The VCG to be used in the calculation. Can be the actual VCG, but is often chosen at a convenient point such as the baseline, so that the results may be easily corrected later for the actual VCG.

Heel Angles for Rollover: The list of angles for which to compute a cross curve. Note that the ellipsis shorthand can be used. If your model isn't entirely closed, be careful not to specify a heel angle large enough that an open edge (e.g., a sheerline with no deck surface) becomes submerged.

Mirror Geometry About Centerplane: If your model represents only half of the hull, check this box to create a "virtual" mirror image for the calculations.

Override Initial Plane Height: To begin the iterations necessary to find an equilibrium flotation plane, Orca3D uses as a first guess a plane that is at the half height of the model. In some cases this is not a good starting point, and you can override it by checking the box and entering the height (in the Rhino World Coordinate system) of the plane that should be used as the starting guess.

Also Write Output to CSV File: As with the Hydrostatics calculation, the numeric results may be saved in a CSV file, which is then easily read into Excel for further processing or plotting.

10.10 STIX Calculation

The OrcaSTIXCriteria command does an ISO 12217-2 STIX calculation and creates a report. This calculation calculates the 6.4 Minimum Righting Energy value and category, the 6.5 Angle of Vanishing Stability value and category, and the 6.6 Stability Index (STIX) factors, values, and design category.

Orca3D STIX Calculation

Description: STIX Analysis

Load Condition

☐ Weight(s) 0 kgf or ☒ Model Sinkage(s) 0 mm
☐ LCG(s) 0 mm or ☒ Model Trim(s) 0 deg
☐ TCG(s) 0 mm or ☒ Model Heel(s) 0 deg
VCG(s) 0 mm

☐ Use Custom Conditions
[How to enter multiple conditions....](#)

Geometry Inputs

Height of CE 0 mm (above DWL) Place..
Depth of CLR 0 mm (below DWL) Place..
Sail Area 0 m² Calculate..
LOA 0 mm Update Bounding Box
LWL 0 mm
Beam 0 mm
Beam WL 0 mm

☒ Get Dimensions from Hydrostatics
☐ Flooded Buoyancy
☐ Mirror About Centerplane

Sort Results By: Displacement

Pre-Float Calculate Cancel Add Objects... Points of Interest... Orca3D Units...

10.11 Finding the Flotation Plane when Adding Weights

Using Orca3D to Find the Flotation Plane When Adding Weights

The Orca3D Hydrostatics & Stability module can be used to simulate a flotation experiment, where a hull is placed in the water and then weights are added at various locations to determine the equilibrium flotation condition. In addition to a report of the final sinkage, heel, and trim, Orca3D can either transform the model so that the Z=0 plane is the equilibrium flotation plane, or a plane can be inserted into the model that represents the equilibrium flotation plane.

The input requirements are:

- A hull model – the hull model can be made up of one or more surfaces, polysurfaces, meshes, and polymeshes. The model does not need to be closed (watertight). Small gaps between surfaces will usually result in small errors. If the deck is not modeled, it will not create a problem unless the resulting condition would cause the deck edge to become submerged. You must be certain that the outward normal direction is correct on all the surfaces or meshes. When using the *dir* command, all the arrows should be pointing into the

water. If the outward normal is incorrect, that surface will deduct from displaced volume, rather than contributing to it.

- The initial flotation condition, including the vertical center of gravity (VCG) – The initial flotation condition is the condition that the vessel floats in before additional weights are added, and it can be specified as:
 - total weight and center of gravity (longitudinal, transverse, and vertical)
 - sinkage, trim, and heel, and VCG
 - total weight, trim or LCG, heel or TCG, and VCG
 - freeboards at two or three locations, and VCG (with only two locations, heel will be assumed to be 0)
 - a plane that you have drawn in Rhino to represent the flotation plane, and the VCG
- A list of additional weights to add, and the LCG, TCG, and VCG of each one
- The water density (salt water, fresh water, or user-defined). This can be set in the Orca3D Properties dialog (default is salt water).

The output will be:

- The Hydrostatics & Stability report, documenting the resulting equilibrium flotation plane by the total displacement, LCG, TCG, VCG, as well as sinkage, trim, and heel (see the Orca3D Help file to learn how these quantities are defined)
- The model transformed to the equilibrium flotation plane, or a plane inserted into the model to represent the equilibrium flotation plane along with text dots at the locations of the center of buoyancy, center of flotation, and center of gravity.

As the first step we will establish the initial flotation condition using the various methods described above. Following that we will add items at various locations and find the equilibrium flotation condition.

Establishing the Initial Flotation Condition

Example 1: The total weight and center of gravity is known from a weight study

In this example, the vessel's total weight and center of gravity is known or estimated, perhaps as the result of a weight study.

1. Select the hull surfaces (again, be sure that the outward normals are correct, using the *dir* command. If they are incorrect, use the *flip* option to correct them). This can be a full model (port and starboard sides) or just one half of a symmetric hull.
2. Start the Hydrostatics & Stability command (in the Orca3D menu, select Stability -> Compute Hydrostatics and Stability)

3. Select the Weight, LCG, and TCG radio buttons. Enter the weight and CG information. If your hull is a half-model, check the “Mirror about Centerplane” box. Check the “Add Plane(s) Representing the Water Surface” box.

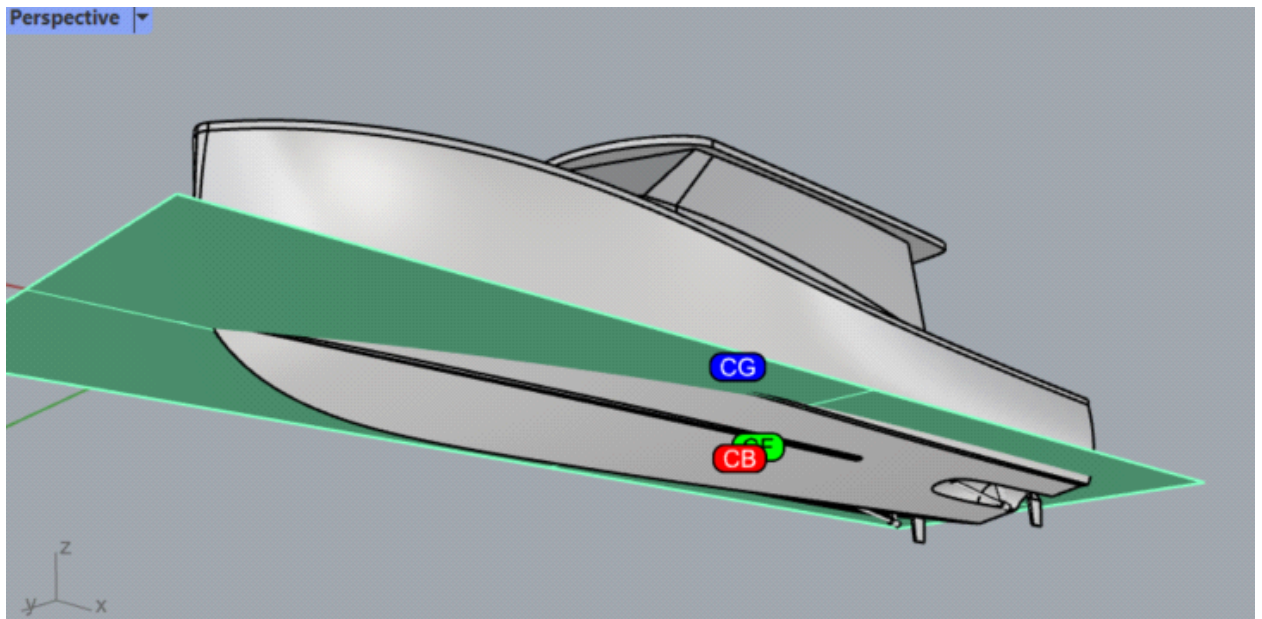
Orca3D Hydrostatics & Stability Analysis ? X

Description:

☒ Weight(s) lbf or ☐ Model Sinkage(s) ft
☒ LCG(s) ft or ☐ Model Trim(s) deg
☒ TCG(s) ft or ☐ Model Heel(s) deg
 VCG(s) ft [How to enter multiple conditions...](#)

☐ Override Initial Plane Height for Free Float Iteration ft
☐ Mirror About Centerplane
☒ Add Plane(s) Representing Water Surface
☐ Transform Model to Resultant Condition
☐ Compute Righting Arm at these Heel Angles e.g. 0.5,...,30,40,...,90
☐ Print Full Output for Heeled Conditions
☐ Also Write Output To CSV File
☐ Use Custom Conditions
 Sort Results By:

4. Click Calculate; the Hydrostatics & Stability report will be created, and a cyan-colored plane will be inserted into the model representing the initial flotation condition. Verify that the flotation plane is as expected.
5. Now you are ready to move on to adding items to find the equilibrium flotation condition.










Example 2: The total weight and center of gravity is known using Orca3D's Weight & Cost Tracking module

In this example, you have used Orca3D's Weight & Cost model to assign materials from your material library, so that Orca3D can compute the weight and CG of each item in your model. This is then summed to get the total weight and CG.

1. If your Weight & Cost model represents the entire vessel (i.e., every item is included in the model), select the hull surfaces, and start the Hydrostatics & Stability command (in the Orca3D menu, select Stability -> Compute Hydrostatics and Stability).
2. Click on the "Get Weight/CG..." button. This will fill the total weight and CG from your Weight & Cost model into the fields for the Weight, LCG, TCG, and VCG. Note that if you have a half model, you will need to double the weight and adjust the TCG to 0.

Orca3D Hydrostatics & Stability Analysis ? X

Description: <input type="text" value="Hydrostatics & Stability Analysis"/>	
<input checked="" type="radio"/> Weight(s)	<input type="text" value="0.000"/> lbf or <input type="radio"/> Model Sinkage(s) <input type="text" value="0"/> ft
<input checked="" type="radio"/> LCG(s)	<input type="text" value="0.000"/> ft or <input type="radio"/> Model Trim(s) <input type="text" value="0"/> deg
<input checked="" type="radio"/> TCG(s)	<input type="text" value="0.000"/> ft or <input type="radio"/> Model Heel(s) <input type="text" value="0"/> deg
VCG(s)	<input type="text" value="0.000"/> ft How to enter multiple conditions...  
  	
<input type="checkbox"/> Override Initial Plane Height for Free Float Iteration	<input type="text" value="2.7543510629501"/> ft
<input type="checkbox"/> Mirror About Centerplane	
<input checked="" type="checkbox"/> Add Plane(s) Representing Water Surface	
<input type="checkbox"/> Transform Model to Resultant Condition	
<input type="checkbox"/> Compute Righting Arm at these Heel Angles	<input type="text" value="0.5...35"/> e.g. 0.5...30,40...90
<input type="checkbox"/> Print Full Output for Heeled Conditions	
<input type="checkbox"/> Also Write Output To CSV File	<input type="text" value="C:\Users\bhays\Documents\Hydrostatics.csv"/> 
<input type="checkbox"/> Use Custom Conditions	
Sort Results By:	<input type="text" value="Displacement"/> 
<input type="button" value="Pre-Float"/> <input type="button" value="Calculate"/> <input type="button" value="Cancel"/> <input type="button" value="Add Objects..."/> <input type="button" value="Points of Interest..."/> <input type="button" value="Orca3D Units..."/> <input type="button" value="Adjust Meshes ..."/>	

3. If your hull is a half-model, check the "Mirror about Centerplane" box. Check the "Add Plane(s) Representing the Water Surface" box.
4. Click Calculate; the Hydrostatics & Stability report will be created, and a cyan-colored plane will be inserted into the model representing the initial flotation condition. Verify that the flotation plane is as expected.
5. Now you are ready to move on to adding items to find the equilibrium flotation condition.
6. If your Weight & Cost model does not represent the entire weight of the vessel, run a Weight

& Cost report to get the modeled weight and CG.

7. Start the Hydrostatics & Stability command. Click on the Calculator icon:



Orca3D Hydrostatics & Stability Analysis ? ×





Description:

☒ Weight(s) lbf or ☐ Model Sinkage(s) ft

☒ LCG(s) ft or ☐ Model Trim(s) deg

☒ TCG(s) ft or ☐ Model Heel(s) deg

VCG(s) ft [How to enter multiple conditions...](#)  

☐ Override Initial Plane Height for Free Float Iteration ft


☐ Mirror About Centerplane

☒ Add Plane(s) Representing Water Surface

☐ Transform Model to Resultant Condition

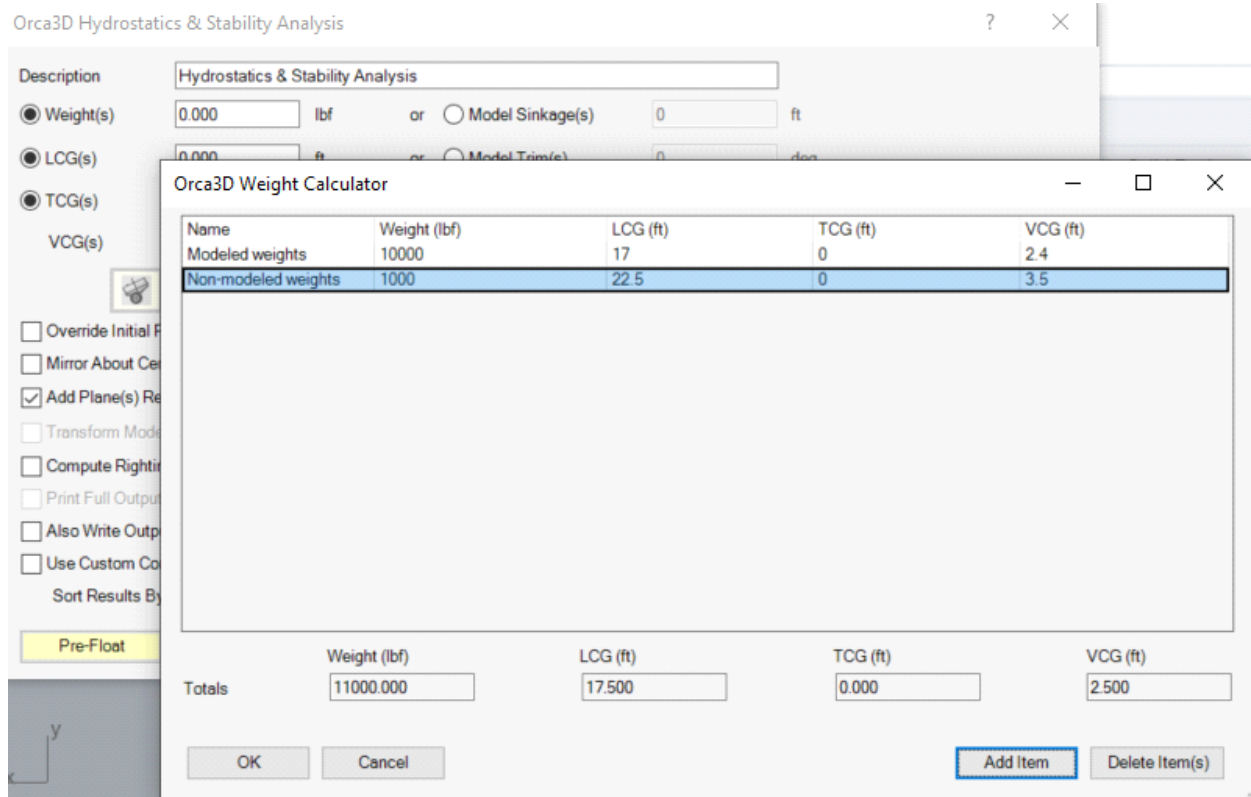
☐ Compute Righting Arm at these Heel Angles e.g. 0.5,...,30,40,...,90

☐ Print Full Output for Heeled Conditions

☐ Also Write Output To CSV File 

☐ Use Custom Conditions

Sort Results By:



8. The Orca3D Weight Calculator is essentially a simple spreadsheet. Click the Add Item button, and enter the Name, Weight, and CG that was shown in the Weight & Cost report (double it first, if you just have a half model).
9. Continue to add items to account for anything that was not included in the Weight & Cost model.
10. Click OK; the total Weight and CG will be entered into the Hydrostatics & Stability dialog.
11. If your hull is a half-model, check the “Mirror about Centerplane” box. Check the “Add Plane(s) Representing the Water Surface” box.
12. Click Calculate; the Hydrostatics & Stability report will be created, and a cyan-colored plane will be inserted into the model representing the initial flotation condition. Verify that the flotation plane is as expected.
13. Now you are ready to move on to adding items to find the equilibrium flotation condition.

Example 3: The Sinkage, Trim, Heel, and VCG are known

In this example, the vessel's Sinkage, Trim, Heel, and VCG are known. Frequently, this is because the vessel was modeled with the Z=0 plane at the design waterline, so the Sinkage, Trim, and Heel are 0.

1. Select the hull surfaces. This can be a full model (port and starboard sides) or just one half of a symmetric hull.
2. Start the Hydrostatics & Stability command (in the Orca3D menu, select Stability -> Compute Hydrostatics and Stability)
3. Select the Model Sinkage, Model Trim, and Model Heel radio buttons. Enter the values. If your hull is a half-model, check the "Mirror about Centerplane" box. Check the "Add Plane(s) Representing the Water Surface" box.

Orca3D Hydrostatics & Stability Analysis

Description: Hydrostatics & Stability Analysis

☐ Weight(s) 11000 lbf or ☒ Model Sinkage(s) 0 ft
☐ LCG(s) 17.5 ft or ☒ Model Trim(s) 0 deg
☐ TCG(s) 0.000 ft or ☒ Model Heel(s) 0 deg
 VCG(s) 2.5 ft

☐ Override Initial Plane Height for Free Float Iteration 2.7543510629501 ft
☐ Mirror About Centerplane
☒ Add Plane(s) Representing Water Surface
☐ Transform Model to Resultant Condition
☐ Compute Righting Arm at these Heel Angles 0.5,...,35 e.g. 0.5,...,30,40,...,90
☐ Print Full Output for Heeled Conditions
☐ Also Write Output To CSV File C:\Users\bhays\Documents\Hydrostatics.csv
☐ Use Custom Conditions
 Sort Results By: Displacement

Pre-Float Calculate Cancel Add Objects... Points of Interest... Orca3D Units... Adjust Meshes ...

4. Click Calculate; the Hydrostatics & Stability report will be created, and a cyan-colored plane will be inserted into the model representing the initial flotation condition. Verify that the flotation plane is as expected.
5. Now you are ready to move on to adding items to find the equilibrium flotation condition.

Example 4: Freeboards are known from actual in-water measurements, and the VCG is known. In this example, the known information is freeboard measurements and the VCG. Remember that if the freeboards are known from actual measurements, it is important to set the water density (in Orca3D Properties) to match that of the water that the vessel was floating in when the freeboard measurements were taken. This will give an accurate weight, LCG, and TCG. If you want to analyze the effect of adding weights in a different water density (for example, your freeboards were taken in a fresh water tank, but you want the analysis in salt water), you can change the water density in the later step where you are finding the equilibrium flotation condition.


1. Select the hull surfaces. This can be a full model (port and starboard sides) or just one half of a symmetric hull.
2. Start the Hydrostatics & Stability command (in the Orca3D menu, select Stability -> Compute Hydrostatics and Stability)
3. Click on the “Create and select planar surface...” icon

Orca3D Hydrostatics & Stability Analysis



Description: Hydrostatics & Stability Analysis

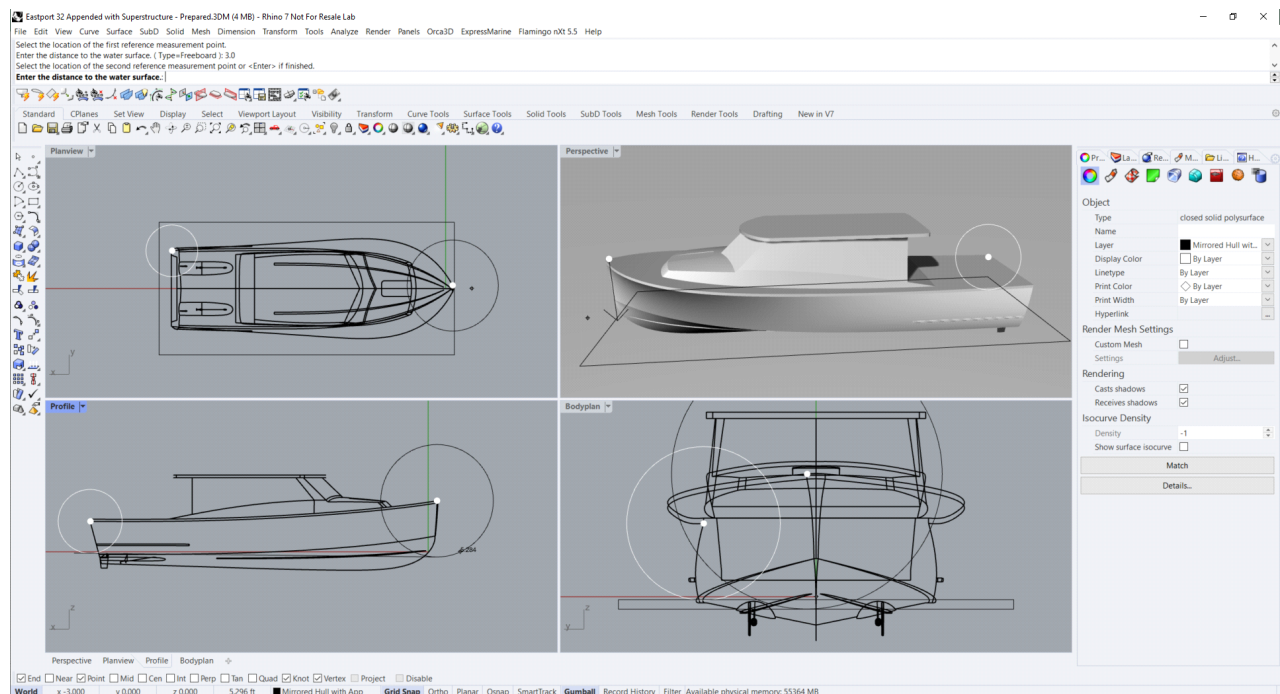
☐ Weight(s) 11000 lbf or ☒ Model Sinkage(s) 0 ft
☐ LCG(s) 17.5 ft or ☒ Model Trim(s) 0 deg
☐ TCG(s) 0.000 ft or ☒ Model Heel(s) 0 deg
 VCG(s) 2.5 ft

[How to enter multiple conditions...](#)


☐ Override Initial Plane Height for Free Float Iteration 2.7543510629501 ft
☐ Mirror About Centerplane
☒ Add Plane(s) Representing Water Surface
☐ Transform Model to Resultant Condition
☐ Compute Righting Arm at these Heel Angles 0.5,...,35 e.g. 0.5,...,30,40,...,90
☐ Print Full Output for Heeled Conditions
☐ Also Write Output To CSV File C:\Users\bhays\Documents\Hydrostatics.csv
☐ Use Custom Conditions
 Sort Results By: Displacement

Pre-Float Calculate Cancel Add Objects... Points of Interest... Orca3D Units... Adjust Meshes ...

4. Follow the prompts to select two or three points on the model where you have measured the freeboard and enter the distance to the water surface. If you finish the command after entering just two points, the vessel will be assumed to have 0 heel. If you enter three points, the heel will be computed, together with the sinkage and trim.





5. When you finish entering the freeboard data, the computed Sinkage, Trim, and Heel will be entered into the fields.
6. If your hull is a half-model, check the “Mirror about Centerplane” box. Check the “Add Plane(s) Representing the Water Surface” box.
7. Click Calculate; the Hydrostatics & Stability report will be created, and a cyan-colored plane will be inserted into the model representing the initial flotation condition. Verify that the flotation plane is as expected.
8. Now you are ready to move on to adding items to find the equilibrium flotation condition.

Example 5: The flotation plane and VCG are known

This is a variation of the previous example. Instead of entering freeboards to establish the flotation plane, in this example it is assumed that you have drawn a plane in the model that represents the initial flotation plane.

1. Select the hull surfaces. This can be a full model (port and starboard sides) or just one half of a symmetric hull.
2. Start the Hydrostatics & Stability command (in the Orca3D menu, select Stability -> Compute Hydrostatics and Stability)
3. Click on the “Select planar surface...” icon

Orca3D Hydrostatics & Stability Analysis ? X

Description: <input type="text" value="Hydrostatics & Stability Analysis"/>					
<input type="radio"/> Weight(s)	<input type="text" value="11000"/>	lbf	or <input checked="" type="radio"/> Model Sinkage(s)	<input type="text" value="0"/>	ft
<input type="radio"/> LCG(s)	<input type="text" value="17.5"/>	ft	or <input checked="" type="radio"/> Model Trim(s)	<input type="text" value="0"/>	deg
<input type="radio"/> TCG(s)	<input type="text" value="0.000"/>	ft	or <input checked="" type="radio"/> Model Heel(s)	<input type="text" value="0"/>	deg
VCG(s)	<input type="text" value="2.5"/>	ft	How to enter multiple conditions...  		

☐ Override Initial Plane Height for Free Float Iteration ft
☐ Mirror About Centerplane
☒ Add Plane(s) Representing Water Surface
☐ Transform Model to Resultant Condition
☐ Compute Righting Arm at these Heel Angles e.g. 0.5,...,30,40,...,90
☐ Print Full Output for Heeled Conditions
☐ Also Write Output To CSV File
☐ Use Custom Conditions
 Sort Results By:

4. Click on the plane that represents the initial flotation condition.
5. When you select the plane, the computed Sinkage, Trim, and Heel will be entered into the fields.
6. If your hull is a half-model, check the “Mirror about Centerplane” box. Check the “Add Plane(s) Representing the Water Surface” box.
7. Click Calculate; the Hydrostatics & Stability report will be created, and a cyan-colored plane will be inserted into the model representing the initial flotation condition. Verify that the flotation plane is as expected.

8. Now you are ready to move on to adding items to find the equilibrium flotation condition.

Adding Items to find the Equilibrium Flotation Condition

Now that the initial flotation condition has been established, we can move on to analyzing the effect of adding additional weights to the boat. As an example, we will add the following:

- 400 lb motorcycle (the example boat, courtesy of Eastport Yachts, conveniently features a transom gate)
- 150 lb inflatable boat with outboard engine (carried on the hard top)




Now that we know the initial flotation condition and VCG using one of the examples above, it is straightforward to analyze the effect of adding one or more additional items.

1. Select the hull surfaces. This can be a full model (port and starboard sides) or just one half of a symmetric hull.
2. Start the Hydrostatics & Stability command (in the Orca3D menu, select Stability -> Compute Hydrostatics and Stability)
3. If your hull is a half-model, check the “Mirror about Centerplane” box. Check the “Add Plane(s) Representing the Water Surface” box.
4. Select the Weight, LCG, and TCG radio buttons. Click the calculator icon:

Orca3D Hydrostatics & Stability Analysis ? X

Description: Hydrostatics & Stability Analysis

☒ Weight(s) 0.000 lbf or ☐ Model Sinkage(s) 0 ft
☒ LCG(s) 0.000 ft or ☐ Model Trim(s) 0 deg
☒ TCG(s) 0.000 ft or ☐ Model Heel(s) 0 deg
VCG(s) 0.000 ft [How to enter multiple conditions...](#)

☐ Override Initial Plane Height for Free Float Iteration 2.7543510629501 ft
☐ Mirror About Centerplane
☒ Add Plane(s) Representing Water Surface
☐ Transform Model to Resultant Condition
☐ Compute Righting Arm at these Heel Angles 0.5,...,35 e.g. 0.5,...,30,40,...,90
☐ Print Full Output for Heeled Conditions
☐ Also Write Output To CSV File C:\Users\bhays\Documents\Hydrostatics.csv
☐ Use Custom Conditions
Sort Results By: Displacement

Pre-Float Calculate Cancel Add Objects... Points of Interest... Orca3D Units... Adjust Meshes ...

5. Enter the Weight and CG from the Initial Flotation Condition, as determined in the examples above.
6. Enter the list of additional weight items and their CG's

Orca3D Hydrostatics & Stability Analysis

Orca3D Weight Calculator

Name	Weight (lbf)	LCG (ft)	TCG (ft)	VCG (ft)
Initial Condition	11000	17.5	0	2.5
Motorcycle	500	28.5	1.5	0.75
Inflatable	150	19	0	8.5

Totals

Weight (lbf) 11650.000 LCG (ft) 17.991 TCG (ft) 0.064 VCG (ft) 2.502

OK Cancel Add Item Delete Item(s)

7. Note that as you enter new items, the total weight and CG is updated at the bottom of the dialog.
8. Click OK; the total weight and CG will be entered into the appropriate fields.
9. Click OK; the Hydrostatics & Stability report will be created, showing the equilibrium flotation condition including Sinkage, Trim, and Heel. A cyan-colored plane will be displayed representing the water surface.

10.12 Grasshopper Components for Hydrostatics

NOTE: The Orca3D Hydrostatics and Stability Grasshopper components are currently in Work-in-Progress (WIP) status. All user feedback and suggestions are welcome!

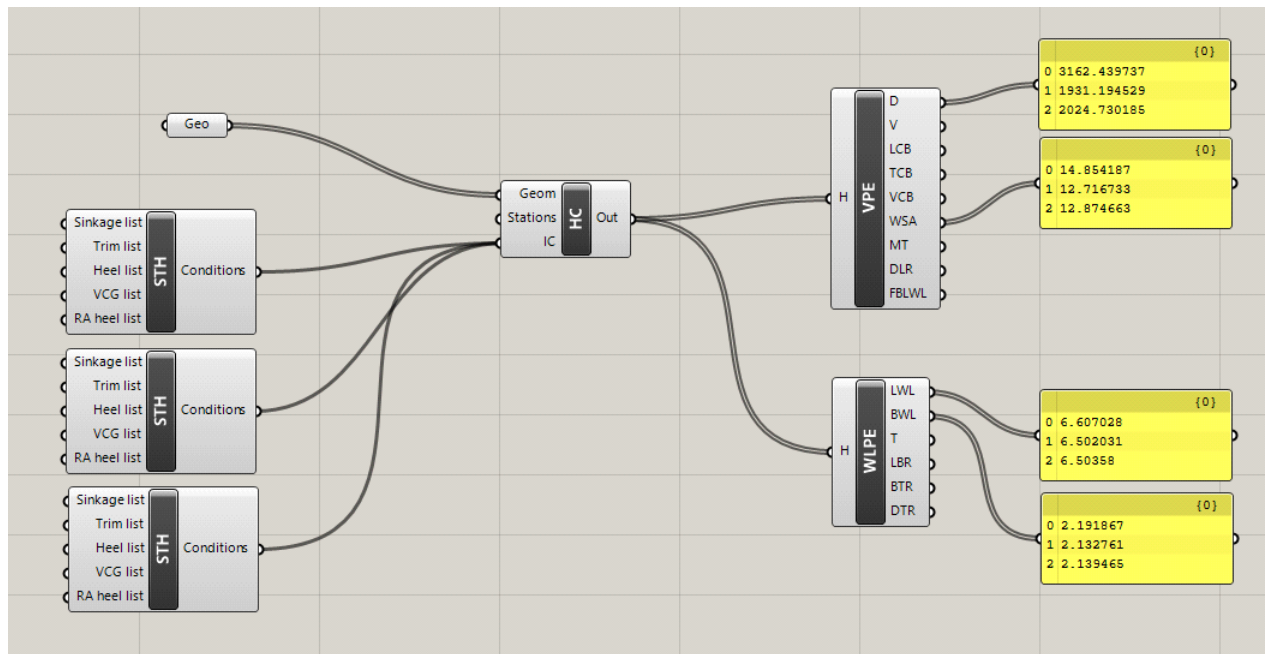
This document describes the basic use of the Orca3D Grasshopper (OGH) components. The OGH components can be found in Grasshopper on the "Orca3D" tab. These components are wrappers around the existing Orca3D functionality and introduce no new engineering content, so for details of the computations please refer to the Orca3D help file or Orca3D technical support (support@orca3d.com). An Orca3D license that includes hydrostatics analysis capability (i.e.,

commercial, educational, or trial Level 1 or Level 2 license) is required to use any of this functionality.

This document assumes the user has a basic familiarity with the workings of Grasshopper and how to build Grasshopper models.

Simple Example

The following is a simple example of an OGH model.

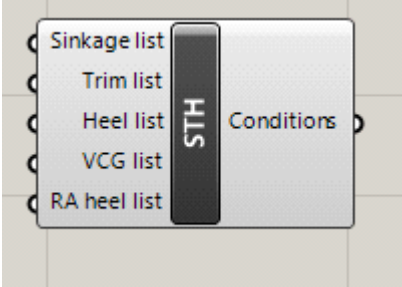
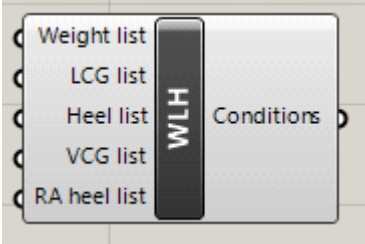
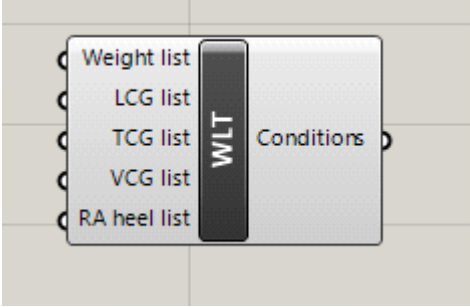
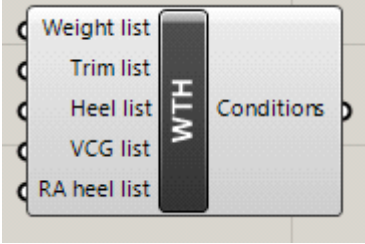
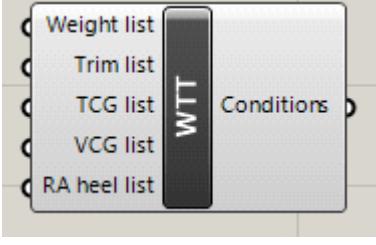


In this example, static geometry from an Orca3D hull assistant and three different fixed sink/trim/heel input conditions are created and used for input to the hydrostatics computation. Values of displacement, wetted surface, waterline length, and waterline beam are extracted and displayed using panel components.

10.12.1 Input Condition Components

Specification of input conditions to Orca3D Hydrostatics Analysis requires the user to define a heave boundary condition (fixed sinkage or weight), a trim boundary condition (fixed trim or longitudinal center of gravity) and a heel boundary condition (fixed heel or transverse center of gravity). The sinkage, trim, and heel boundary conditions lock the model in the specified axis whereas the weight, CG boundary conditions use an iterative solver to balance the forces or moments for that degree of freedom. There are five different input condition components available to the user representing the most common combination of these boundary conditions. They include the following:

Name (Nickname)	Nickname	Description	

SinkTrimHeelConditions	STH	Creates hydrostatics input condition objects for fixed sink, trim, and heel	
WeightLCGHeelConditions	WLH	Creates hydrostatics input condition objects for weight (iterate sinkage), LCG (iterate trim), and fixed heel	
WeightLCGTCGConditions	WLT	Creates hydrostatics input condition objects for weight (iterate sinkage), LCG (iterate trim), and TCG (iterate heel)	
WeightTrimHeelConditions	WTH	Creates hydrostatics input condition objects for weight (iterate sinkage), fixed trim, and fixed heel	
WeightTrimTCGConditions	WTT	Creates hydrostatics input condition objects for weight (iterate sinkage), fixed trim, and TCG (iterate heel)	

In addition to the boundary conditions, each condition component allows the user to specify vertical center of gravity (VCG). This input is required if the iterative free flotation solver is applied.

As is customary with Grasshopper components, each of these inputs may be a single value or collection of values. If multiple values are given for one or more of the inputs, then all combinations of input conditions are created. For example, when using STH if you specify 1 sinkage, 2 trims, 4 heels, and 2 VCG's, then 16 input conditions will be created.

A list of zero or more additional heel angles may also be specified via the RA heel list. Specifying additional righting arm heel angles for an input condition component does not result in additional conditions being created but each of the conditions created will be calculated for the specified condition plus each one of the additional heel angles specified. In our STH example, if you specified 5 heel angles, this would result in 80 hydrostatics solutions being computed.

10.12.2 Computation Component

The Hydrostatics Calculation Component (HCC) is the GH component that does the actual hydrostatics computation. The HCC takes 3 arguments: a list of Geometry (Geom), a list of Stations (Stations), and a list of Input Conditions (IC).



The Geometry list may be any combination of meshes, surfaces, sub-d surfaces, and b-reps. Geometry may be selected from the Rhino model using the geometry collection component or may be generated by other Grasshopper components. Unknown geometry types are ignored. Currently it is assumed that the input geometry includes port and starboard side geometry, i.e., it is fully mirrored.

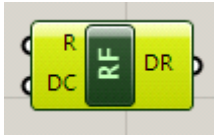
The station list takes a list of station locations. The specification of station locations is identical to that used in the standard OrcaSections command. If no station list is defined, any stations previously defined using the OrcaSections command will be used for section-based hydrostatics. An empty list of stations will result in skipping any station-based computations or output.

The input condition list contains the output of 1 or more input condition components. Input condition types may be mixed.

Hydrostatics computations are expensive and models with multiple conditions are calculated serially so care should be taken to avoid large numbers of unnecessary conditions. Duplicate input conditions will be computed multiple times.

The collection of output (Out) will contain one result for each input condition plus one result for each angle in the RA heel list. For example, if there are 2 input conditions where they have 2 and 3 items in the RA Heel Angle list respectively, 7 results will be returned. Order of the Out collection is the same as the order of the input condition collection. Results may also be matched with an input

condition by using the ResultFinder (RF) component.



The RF component takes 2 inputs: a collection of results (R) from one or more Hydrostatics components and single desired condition (DC). It will return the single hydrostatics result corresponding to the DC. Comparison is done by comparing all input condition parameters. If the same input condition is calculated more than once, or in the case of an RA Heel List, RF will return the first result found in the results list.

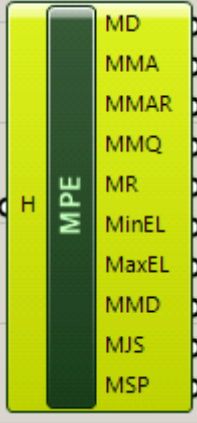
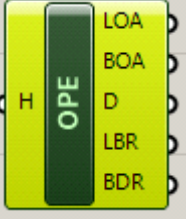


10.12.3 Result Extraction

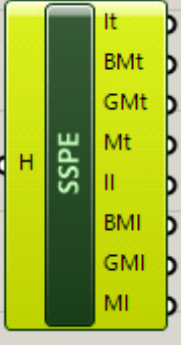
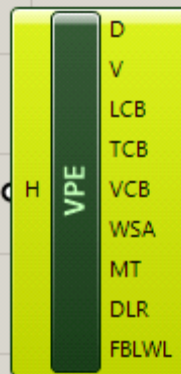
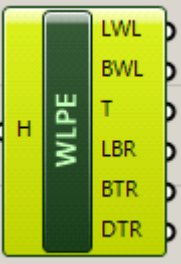
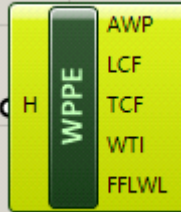
Obtaining numeric result values for downstream computations is done using a type of component called an extractor. There are three general types of extractors: group, generic, and transformation. Extractors generally only extract a subset of numerical values from results. All extractors can operate on a list of one or more results and will return results accordingly.

Group Extractors

Group extractors extract related values from the results list. Each group value being extracted will have one number in the output list, preserving input order. The extractors are as follows:

Name & Description	Picture	Outputs
CoefficientParametersExtractor - Extracts coefficient parameters from a hydrostatics result		<ul style="list-style-type: none"> • Block Coefficient • Prismatic Coefficient • Vertical prismatic coefficient • Maximum section area coefficient • Waterplane coefficient • Wetted surface coefficient
LoadConditionParametersExtractor - Extract load condition parameters from a hydrostatics result		<ul style="list-style-type: none"> • Sink (if fixed sink) • Trim (if fixed trim) • Heel (if fixed heel) • Weight (if weight is specified) • Longitudinal Center of Gravity (if LCG is specified) • Transverse Center of Gravity (if TCG is specified) • Fluid Density

<p>MeshingParametersExtractor - Extract meshing parameters from a hydrostatics result</p>		<ul style="list-style-type: none"> • Mesh density • Mesh max angle • Mesh max aspect ratio • Mesh min quads • Mesh refinement • Mesh min edge length • Mesh max edge length • Mesh max distance • Mesh jagged seams • Mesh simple planes
<p>OverallParametersExtractor - Extract overall parameters from a hydrostatics result</p>		<ul style="list-style-type: none"> • Length overall • Beam overall • Depth • Length to beam ratio • Beam to depth ratio
<p>ResultantAttitudeParametersExtractor – Extract resultant attitude parameters from a hydrostatics result</p>		<ul style="list-style-type: none"> • Resultant sinkage • Resultant trim • Resultant heel
<p>SectionalParametersExtractor - Extracts sectional parameters from a hydrostatics result</p>		<ul style="list-style-type: none"> • Maximum sectional area • Longitudinal location of max sectional area • Longitudinal location of max sectional area as a percentage of waterline length

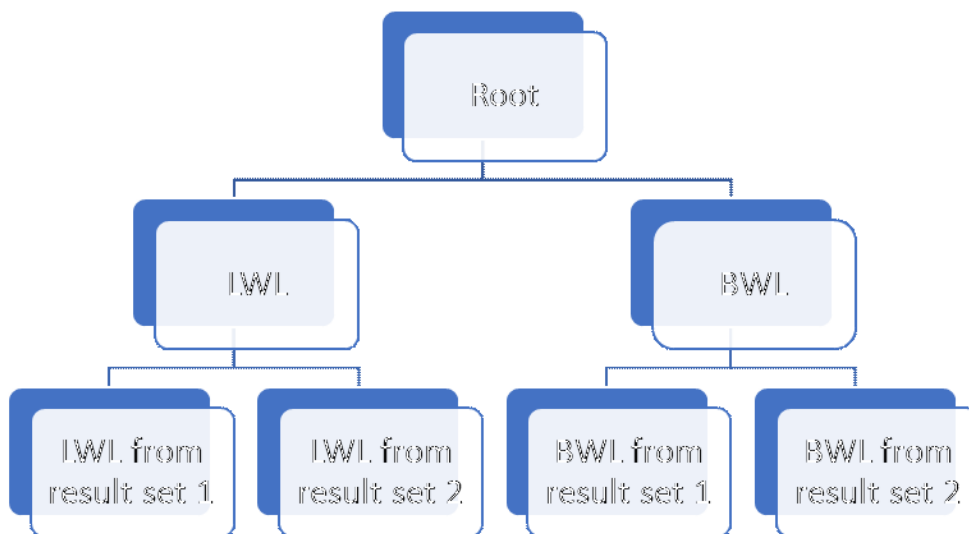
<p>StaticStabilityParametersExtractor</p> <p>- Extracts static stability parameters from a hydrostatics result</p>		<ul style="list-style-type: none"> • Waterplane transverse moment of inertia • Transverse metacentric radius • Transverse metacentric height from the VCG • Transverse metacentric height from the flotation plane • Waterplane longitudinal moment of inertia • Longitudinal metacentric radius • Longitudinal metacentric height from the VCG • Longitudinal metacentric height from the flotation plane
<p>VolumeParametersExtractor</p> <p>- Extracts volume parameters from a hydrostatics result</p>		<ul style="list-style-type: none"> • Displacement • Volume • Longitudinal center of buoyancy • Transverse center of buoyancy • Vertical center of buoyancy • Wetted surface area • Moment to trim • Displacement-length ratio • Longitudinal center of buoyancy expressed as a fraction of waterline length
<p>WaterlineParametersExtractor</p> <p>- Extracts waterline parameters from a hydrostatics result</p>		<ul style="list-style-type: none"> • Waterline length • Waterline beam • Draft • Length-beam ratio • Beam-draft ratio • Depth-draft ratio
<p>WaterplaneParametersExtractor</p> <p>- Extracts waterplane parameters from a hydrostatics result</p>		<ul style="list-style-type: none"> • Waterplane area • Longitudinal center of flotation • Transverse center of flotation • Weight to immerse • Longitudinal center of flotation expressed as a fraction of waterline length

Generic extractor

Generic extraction is done using the Hydrostatics Parameter Extractor which allows a user to extract a specified list of result values. The input arguments are one or more value names and one or more hydrostatics results.

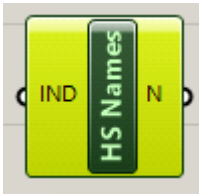


A complete list of all hydrostatics value names that are available can be found by using the Hydrostatics Parameter Name List Component (see below). Results are returned using a GH data tree structure. The 2nd level of the data tree corresponds to the value names and the 3rd level to the result set. The following example illustrates the tree resulting from extracting waterline length and beam from 2 hydrostatic result sets.



The tree can be manipulated like any other tree in GH. For example, the flatten component can be used to get a collection of all the leaves. The branch component can be used to obtain all the leaves in one branch. The flip component can be used to invert the 2nd and 3rd levels of the data tree (in other words, the leaves in each branch contains all values for a particular result set).

The Parameter Name List Component takes a collection of indices and returns a collection of names that are understood by the Hydrostatics Parameter Extractor.

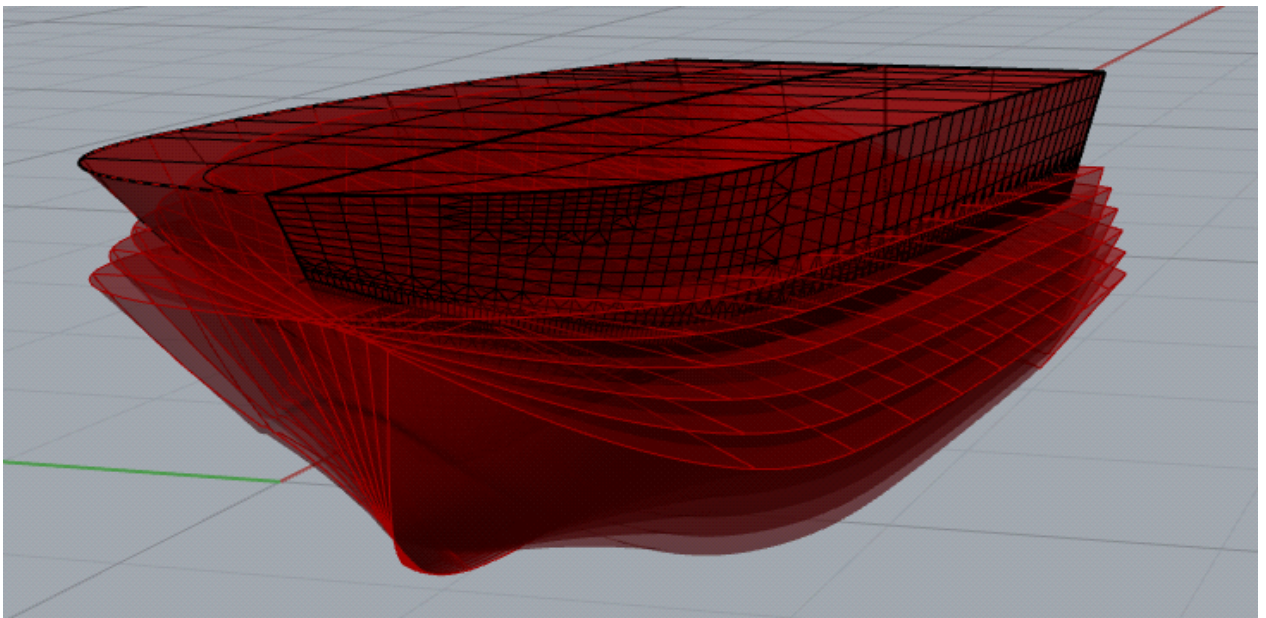


Transformation Extractor

The transformation extractor is used to extract the transformation matrix that results from a hydrostatics equilibrium calculation.



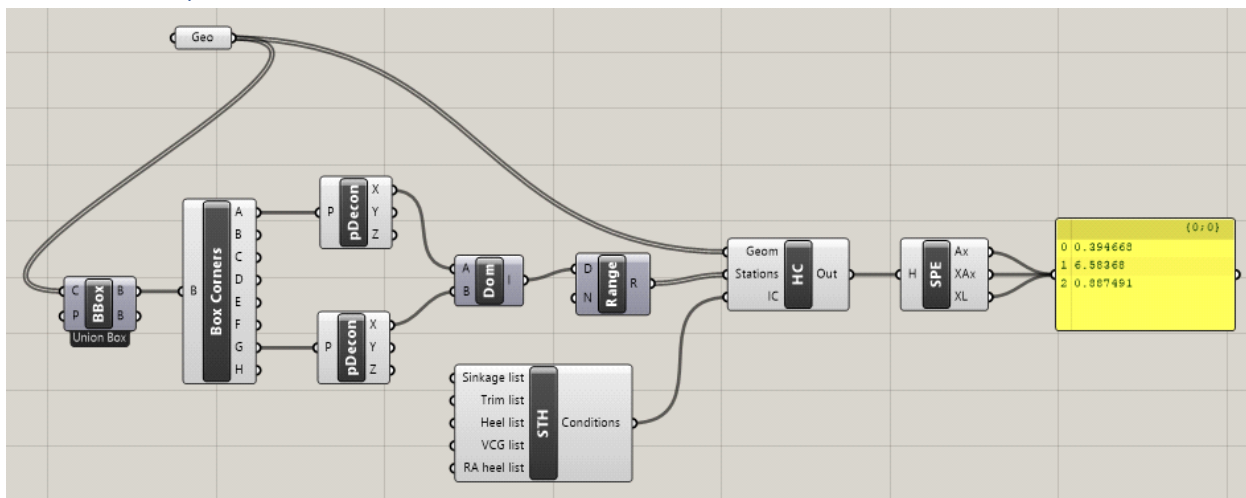
The transformation extractor takes a collection of hydrostatics results and returns a GH Generic transformation for each result set that can be used with the GH transform component to transform geometry. The transformed geometry can be displayed or used for further analysis. It should be noted that when using the GH transform component with multiple geometry objects and multiple transformations (from multiple input conditions) that the first transform will be applied to the first geometry object and the second transform will be applied to the second geometry object, etc. If you wish to apply multiple transformations to a single hull that consists of multiple geometry objects, the Group component should be used.



10.12.4 Examples

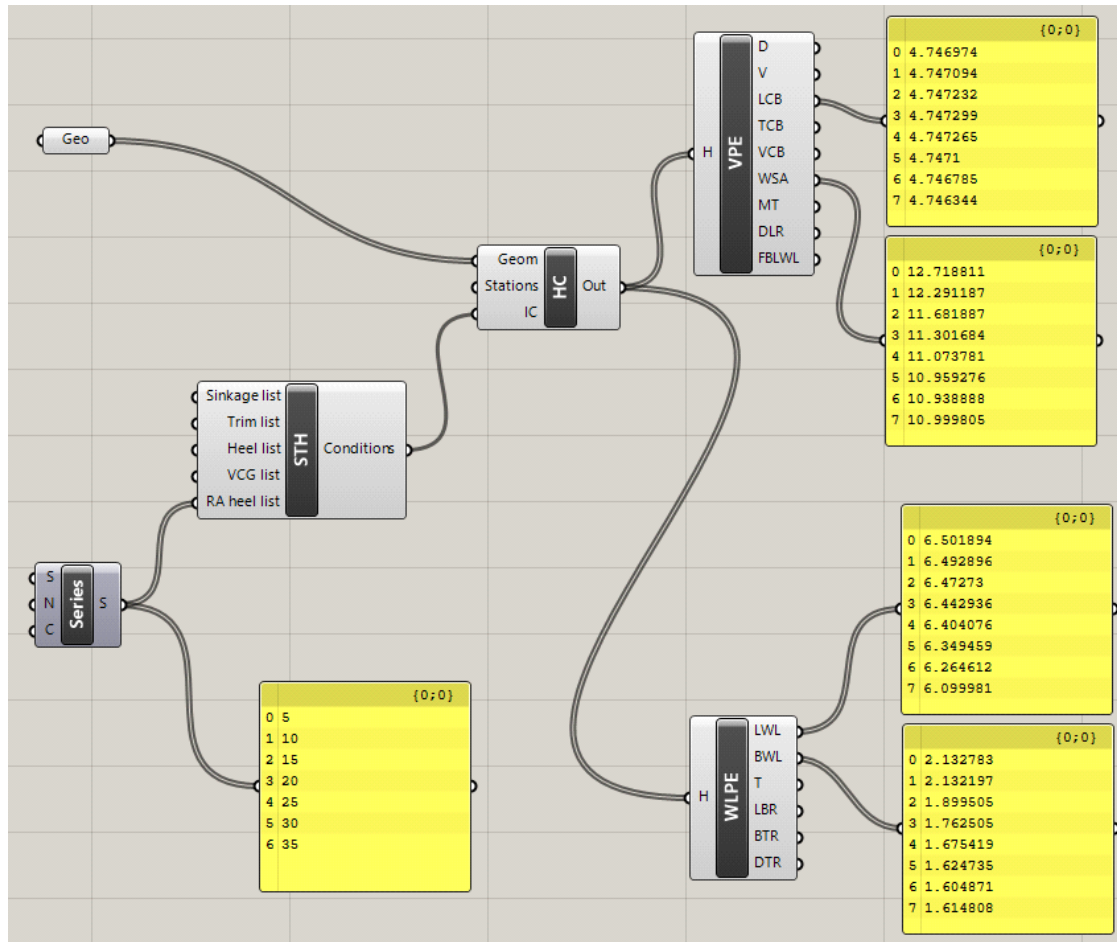
Several example Orca3D Grasshopper examples are provided in the subfolder “Sample data” in the Orca3D installation folder. These are described below.

Station Example



In the station example, a hull created from an Orca3D Hull Assistant is used as input. The geometry is sent to both the HC (Hydrostatics Calc) component and the BBox (Bounding Box) component. The results of the minimum and maximum points from the BBox calculation are used as input pDecon (Point Deconstruct) to get their X values. The X values are used as input to Dom (Construct Domain) which is then used to create a list of numbers using Range. The list of numbers along with the geometry and a simple STH Condition (SinkTrimHeel) component are used as input to HC (Hydrostatics Calc) component. The hydrostatics output is sent to SPE (Sectional Parameter Extractor) to get the section data which is then displayed in the panel.

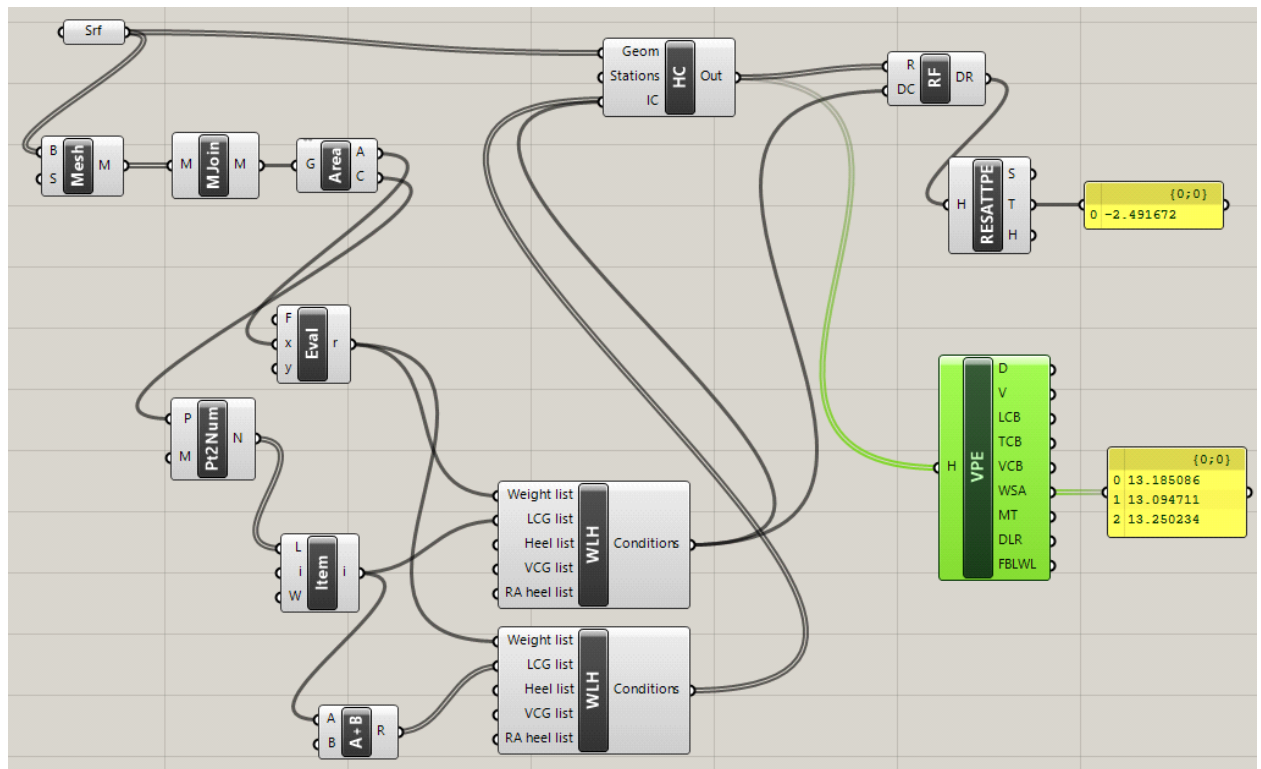
Righting Arm Example



In this example, the series component is used to generate a range of 7 heel angles starting at 5 in increments of 5 degrees. This list is used to set the RA heel list parameter in the STH (SinkTrimHeel) component. Results from the HC (hydrostatics component) are sent to the VPE (volume parameter extractor) and WLPE (waterline parameter extractor) to extract LCB, WSA (wetted surface area), LWL (length water line) and BWL (beam waterline).

More Complex Example

This is a more complex example of what can be done with a Grasshopper model:



This example illustrates a wetted surface study as a function of LCG where both weight and LCG are computed from the geometry. As in the last model, the geometry is obtained from an Orca3D model. The geometry is piped to 2 places, one path is the weight and LCG estimate and the other is the hydrostatics object.

Following the weight and LCG path, the input surfaces are converted to a collection of meshes. The MJoin component converts the meshes to a single mesh. The Area component calculated area and centroid of the single mesh. The area result is piped to an Eval component which has a parametric equation to compute weight from area. The computed weight is then sent to both WLH (WeightLCGHeel) components. The centroid is sent to the P2Num component which converts the point X, Y, and Z to a list of numbers. The Item component gets the x value from the point value list to use for LCG. This LCG is sent to the first WLH component directly. The LCG is also sent to an addition component where 2 fixed offsets, one positive and one negative are added to it. The 2 new LCG values are sent to another WLH component. Two separate WLH components were used so that one could also be sent to the result finder. The results of both WLH components are sent to an HC (hydrostatics computation) component.

The results of the HC component are sent to an RF (result finder) component to find the middle LCG result. This middle LCG result is sent to an RESATPPE (resultant attitude parameter extractor) which extracts the resulting trim value which is displayed in a panel. All three hydrostatics results are also sent to a VPE component (volume parameter extractor) and the resulting wetted surface area values are displayed in a panel.

Part

XI

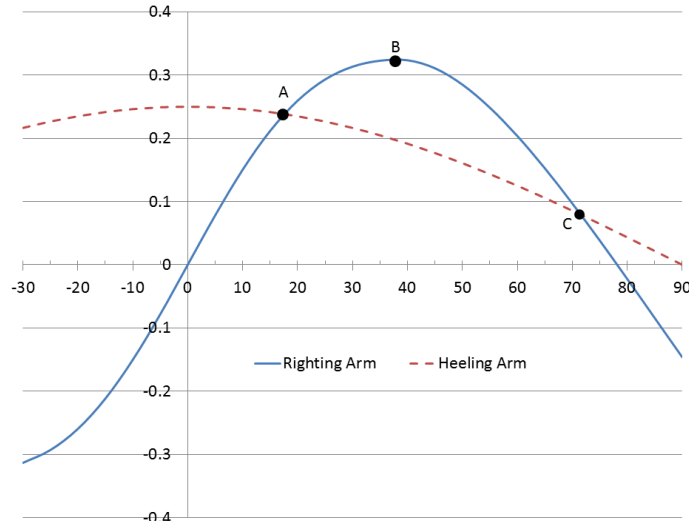
11 Stability Criteria Analysis

11.1 Introduction

Intact stability analysis is performed on models to ensure that, when built, they will meet the criteria that are set by standards organizations such as USCG, ISO, and IMO. These standards are set to ensure the safety of vessels while in their operational environments.

Stability can be approximately evaluated by examining the metacentric height (GM_T) alone. However, on some vessels, particularly those with small freeboard and with righting arm curves that are concave down at the origin, this approximation can result in an overestimation of the vessel's stability.

In order to fully evaluate the stability of the vessel, its righting arm is evaluated over a large range of heeling angles. Figure 1 below shows two graphs where point A is the angle of steady heel or angle at equilibrium, point B is the point of maximum stability, and point C is the angle of vanishing stability.



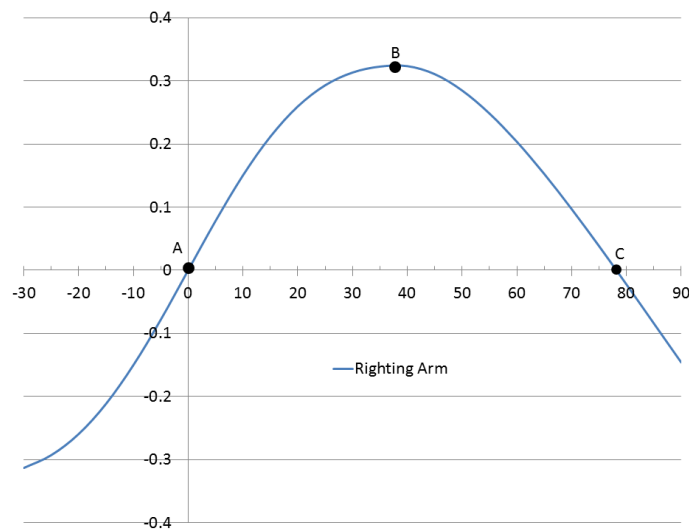


Figure 1: Curves showing three notable stability angles

Terms

Criteria Set: a list of criteria from a certain source (e.g., USCG, IMO, etc.)

Criterion: a list of limits and can also contain a heeling arm to be applied to the model.

Limit: a single inequality that the model must meet.

Heeling Arm: works in opposition to the righting arm, or GZ.

Flow Chart

Figure 2 shows a flow chart of how the three different commands and various forms work with each other to define, edit, and select the criteria to run. The following sections will go into detail on how to use each.

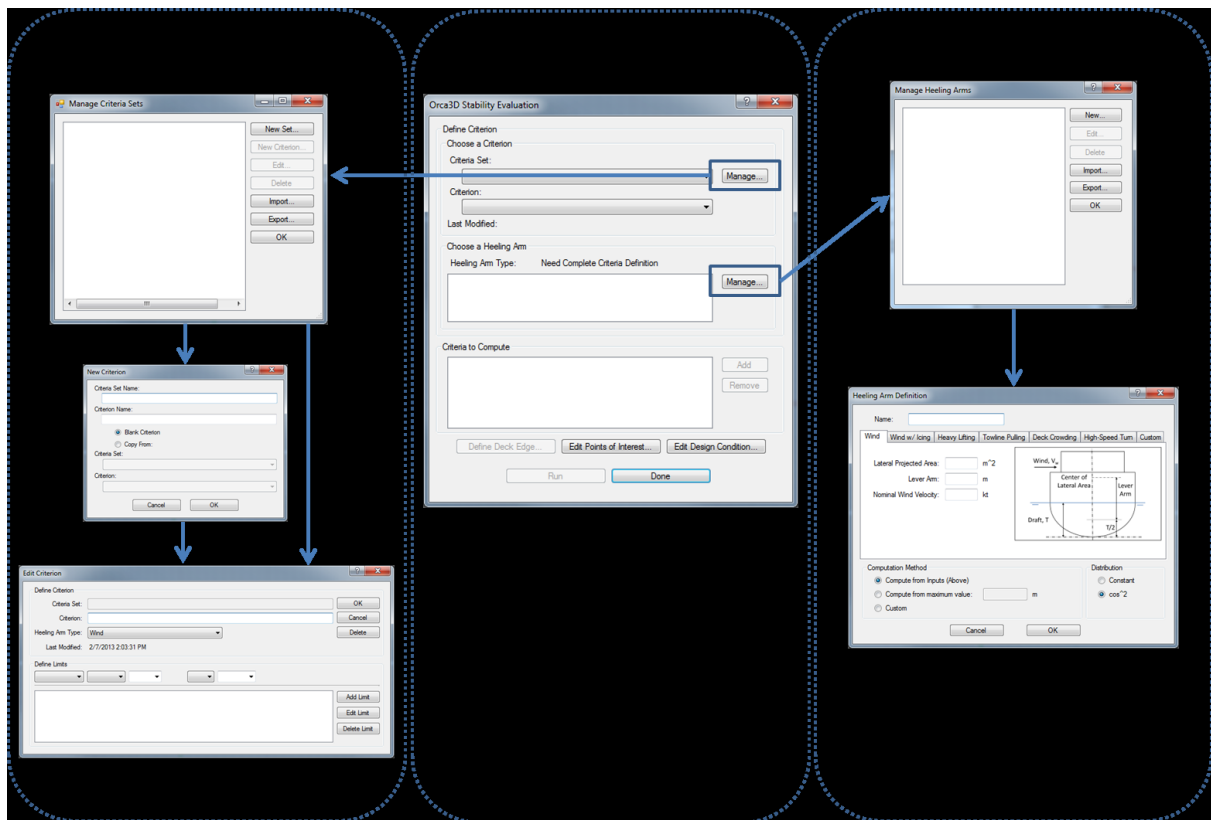


Figure 2: Flowchart

11.2 The Stability Evaluation Form (OrcaStabilityCriteria)

There are three sections in the form: two for defining a criterion to analyze and one that shows the criteria that have been selected.

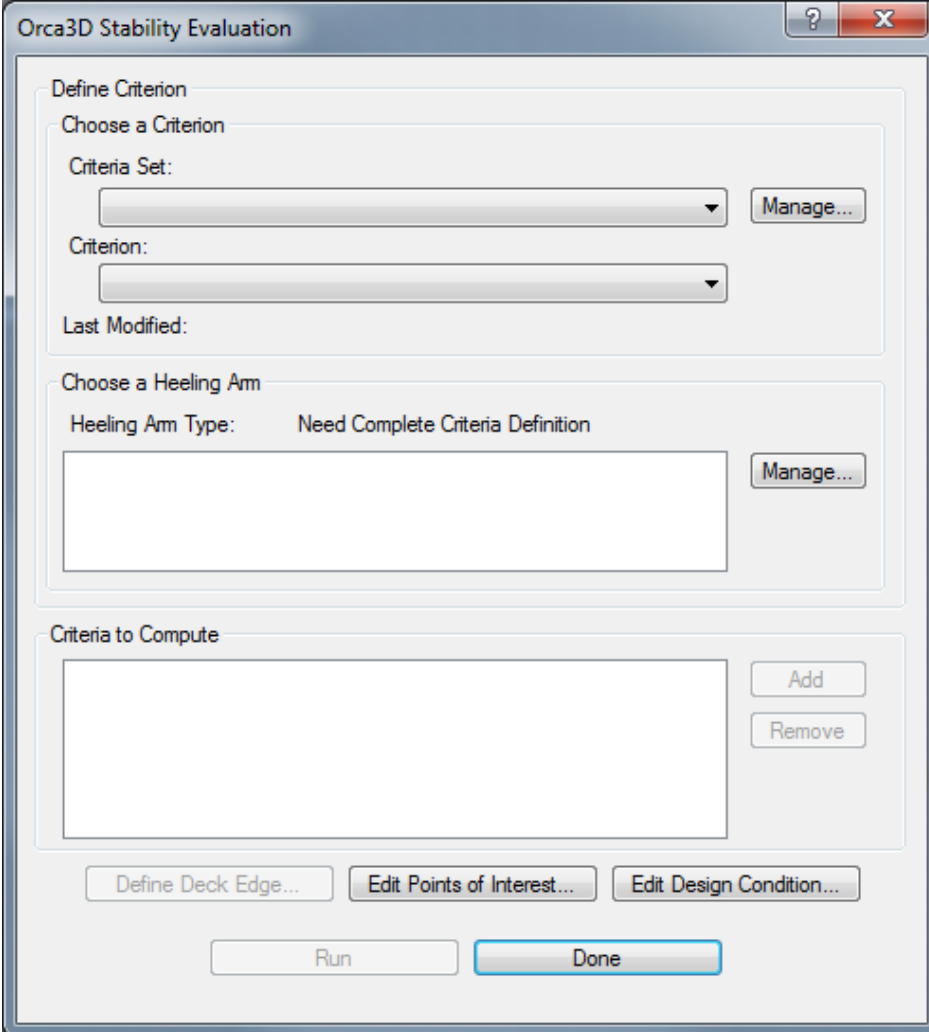
The image shows a software dialog box titled "Orca3D Stability Evaluation". It has a standard Windows-style title bar with a question mark icon and a close button (X). The dialog is divided into three main sections. The top section, "Define Criterion", contains two dropdown menus: "Criteria Set:" and "Criterion:", each followed by a "Manage..." button. Below these is a "Last Modified:" label. The middle section, "Choose a Heeling Arm", has a label "Heeling Arm Type:" followed by the text "Need Complete Criteria Definition" and a large empty rectangular box with a "Manage..." button to its right. The bottom section, "Criteria to Compute", features a large empty rectangular box with "Add" and "Remove" buttons to its right. At the very bottom of the dialog are three buttons: "Define Deck Edge...", "Edit Points of Interest...", and "Edit Design Condition...". At the bottom center are two buttons: "Run" and "Done".

Figure 3: Stability Criteria Evaluation Form

In the uppermost section, you use the two dropdowns to select a criterion. To add, edit, import, or export a criterion, use the 'OrcaManageStabilityCriteria' command, which is also available through the 'Manage...' button.

When a criterion is selected in the top section, the middle section will populate with the heeling arms applicable to that criterion. Heeling arms can be managed using the 'OrcaManageHeelingArms' command, or by clicking the 'Manage...' button in this section.

Once a criterion is selected and, if applicable, a heeling arm is selected, click the 'Add Definition' button to add it to the queue of criteria to be computed. If one of the limits in any of the criteria needs a deck edge definition, the 'Define Deck Edge...' button will be enabled. To define a deck edge, select a curve or surface edge that will represent it. If the hull is not to be mirrored about centerline, both port and starboard deck edges must be selected.

Buttons are also available to edit or define points of interest and the design condition. These buttons link to 'OrcaPointsOfInterest' and 'OrcaDefineDesignCondition,' respectively.

At the bottom of the form 'Run' will start the analysis, and 'Done' will save the entries on the form but not start the analysis.

11.3 Creating a New Criteria Set (OrcaManageStabilityCriteria)

To create or edit criteria sets, use the command 'OrcaManageStabilityCriteria.' This command utilizes the 'Manage Criteria Sets' form shown below in Figure 4.

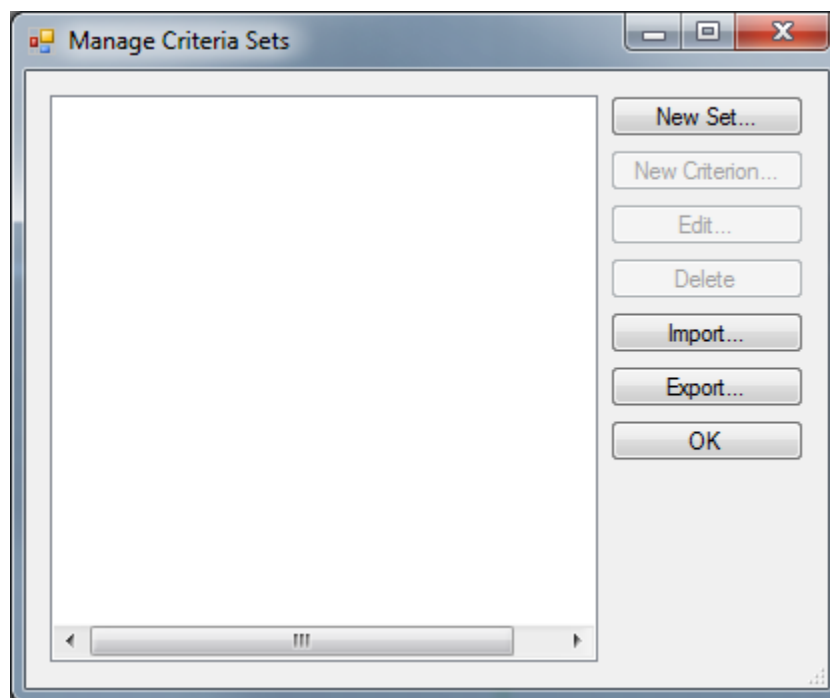


Figure 4: Manage Criteria Set

To create a new set, the 'New Set...' button will bring you to the 'New Criterion' form shown below in Figure 5. The 'Edit...' button will have one of two behaviors. If a criteria set is selected, it will show a dialog to edit the name of the set; if anything else in the tree is selected, it will bring you to the 'New Criterion' form shown below in Figure 5, but with the criteria set name filled out and unchangeable. The other two buttons allow you to import and export the criteria sets. These files are in XML form. Importing will append the new criteria to the existing ones. The criteria are stored globally, not with the model.

This is the 'New Criterion' form, where you can enter the name for the criteria set and name for your criterion. If there are other defined criteria, you can select the 'Copy From:' radio button and then select the desired criterion using the dropdowns.

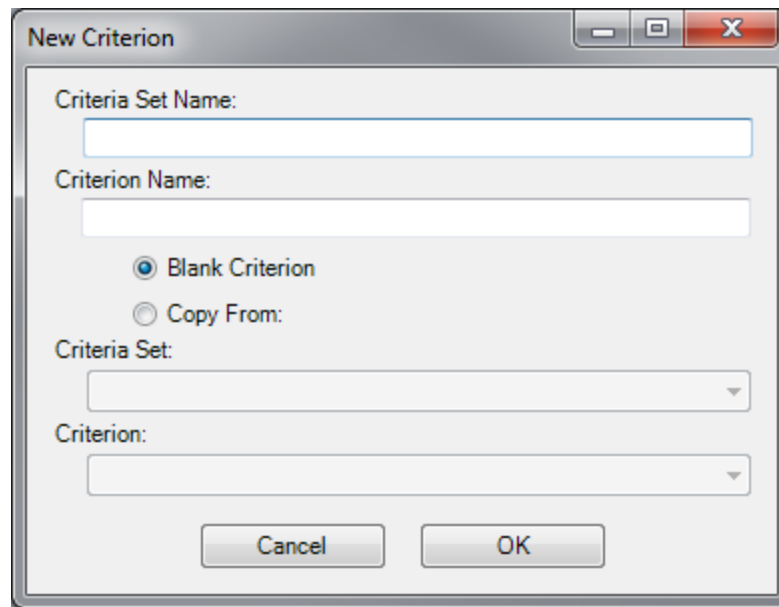
A screenshot of a 'New Criterion' dialog box. The dialog has a title bar with 'New Criterion' and standard window controls. Inside, there are two text input fields: 'Criteria Set Name:' and 'Criterion Name:'. Below these are two radio buttons: 'Blank Criterion' (which is selected) and 'Copy From:'. Under the radio buttons is a dropdown menu labeled 'Criteria Set:'. Below that is another dropdown menu labeled 'Criterion:'. At the bottom are 'Cancel' and 'OK' buttons.

Figure 5: New Criterion Form

Once an option is selected and 'OK' is clicked, you will define the limits for this first criterion of the criteria set.

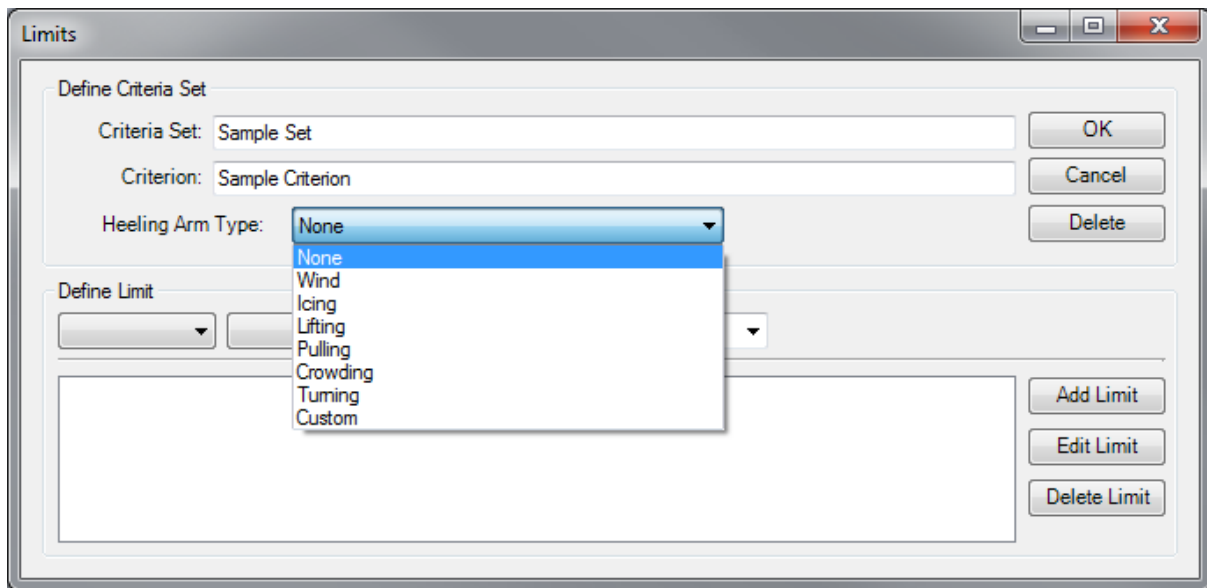
Copying limits can be especially helpful when using the same limiting criteria for a variety of heeling arms, which require several limits to describe.

To edit a preexisting criterion, select the criterion or one of its limits from the tree and click "Edit..." to start editing using the 'Limits' form, discussed in the next section.

To delete anything in the tree, select it from the tree and click "Delete..." and confirm the deletion.

11.4 Defining and Editing the Limits of a Criterion

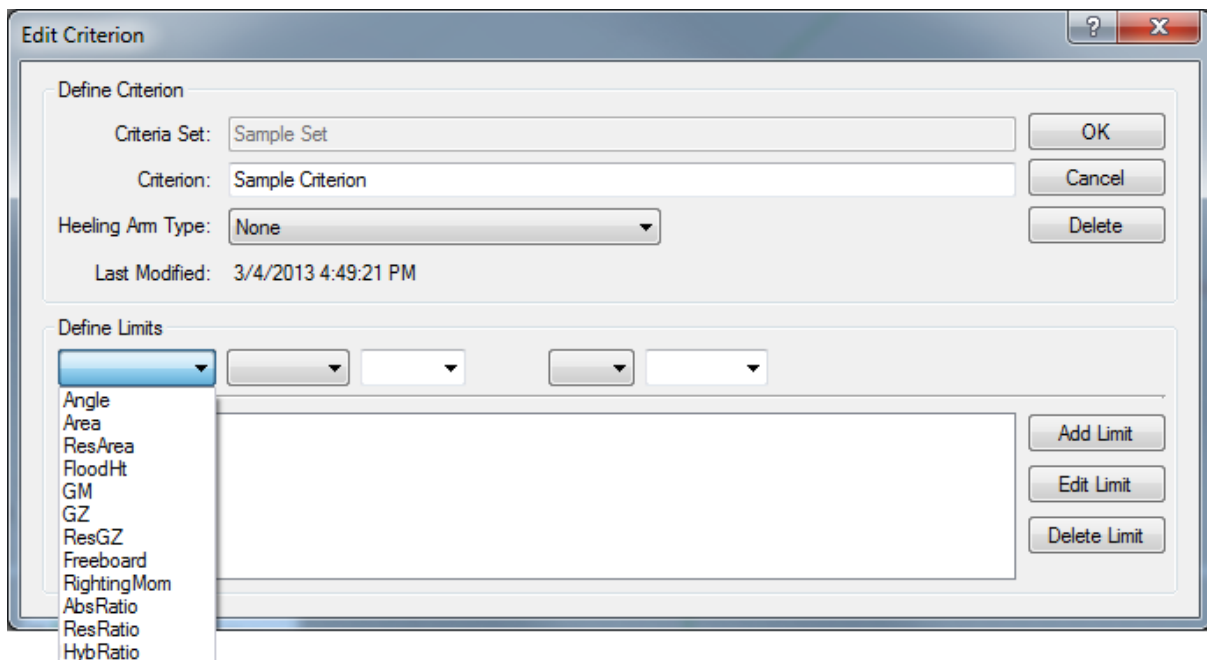
The upper half of the form has fields for the names of the set and the criterion, and a dropdown for the type of heeling arm to apply to the criterion.



The 'Limits' dialog box is shown. It has a title bar with standard window controls. The main area is divided into two sections. The top section, 'Define Criteria Set', contains text boxes for 'Criteria Set' (Sample Set) and 'Criterion' (Sample Criterion), and a dropdown for 'Heeling Arm Type' (None). The bottom section, 'Define Limit', contains a dropdown menu that is open, showing a list of options: None, Wind, Icing, Lifting, Pulling, Crowding, Turning, and Custom. To the right of the 'Define Criteria Set' section are buttons for 'OK', 'Cancel', and 'Delete'. To the right of the 'Define Limit' section are buttons for 'Add Limit', 'Edit Limit', and 'Delete Limit'.

Figure 6: Limits Form, Heeling Arm Type

Limits are defined and edited in the lower half of the form. The first dropdown in the 'Define Limit' box, contains the following options:

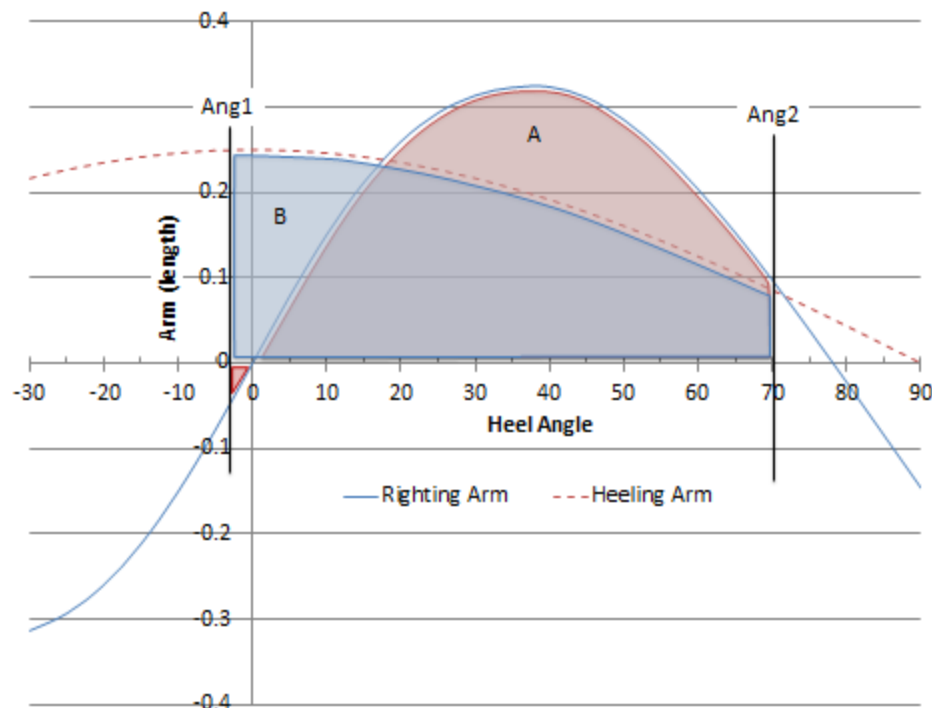


The 'Edit Criterion' dialog box is shown. It has a title bar with a question mark icon and a close button. The main area is divided into two sections. The top section, 'Define Criterion', contains text boxes for 'Criteria Set' (Sample Set) and 'Criterion' (Sample Criterion), and a dropdown for 'Heeling Arm Type' (None). The bottom section, 'Define Limits', contains a dropdown menu that is open, showing a list of options: Angle, Area, ResArea, FloodHt, GM, GZ, ResGZ, Freeboard, RightingMom, AbsRatio, ResRatio, and HybRatio. To the right of the 'Define Criterion' section are buttons for 'OK', 'Cancel', and 'Delete'. To the right of the 'Define Limits' section are buttons for 'Add Limit', 'Edit Limit', and 'Delete Limit'.

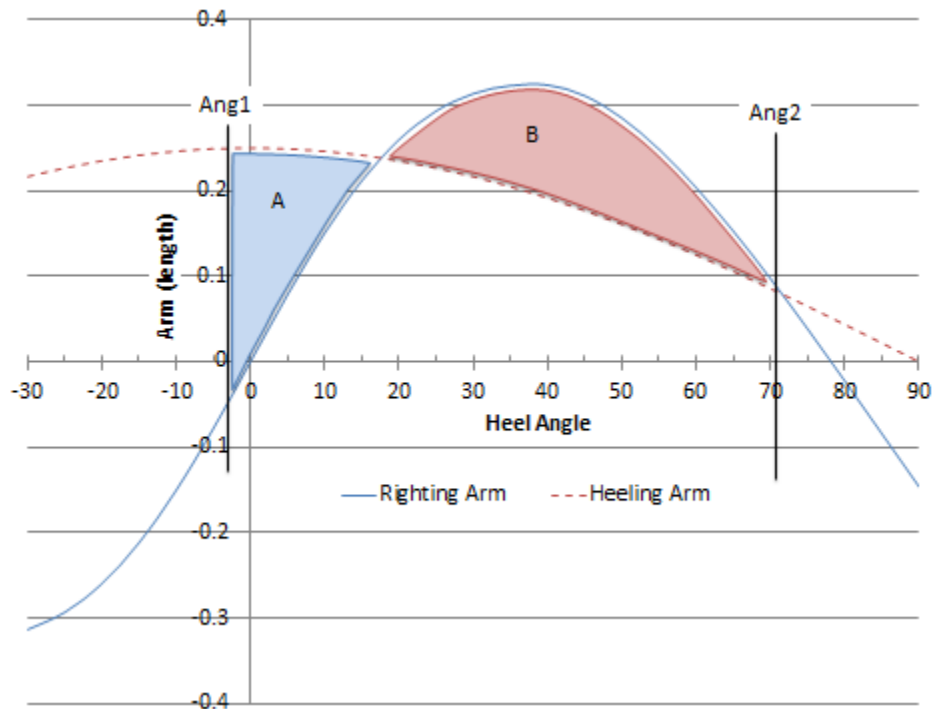
Figure 7: Type of Limit

- **Angle:** can be used to query a specific angle or a range between two angles

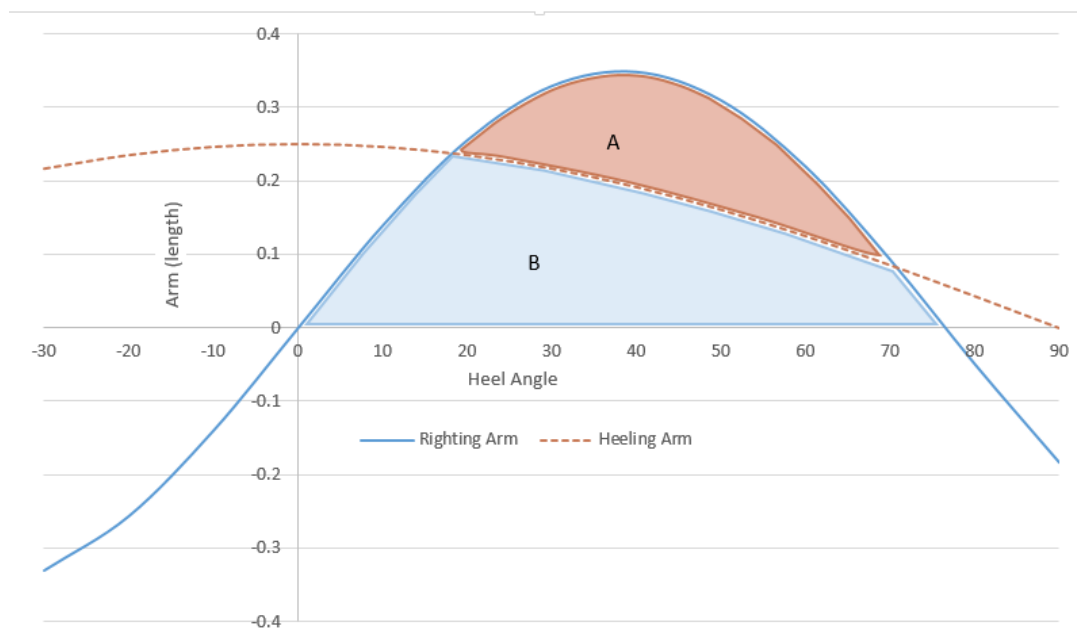
- **Area:** area under the curve between two angles; area under the axis is counted as negative
- **ResArea:** the difference between the area under the righting arm curve and the area under the heeling arm curve, between two angles
- **FloodHt:** minimum distance from the points of interest marked as 'Flood' to the waterline; negative if submerged
- **GM:** metacentric height (at zero heel)
- **GZ:** righting arm (not the difference in righting and heeling)
- **ResGZ:** GZ less any heeling arm present
- **Freeboard:** The smallest distance between the water and the deck edge
- **RightingMom:** righting moment without consideration of heeling moment
- **AbsRatio:** the ration of the net-signed-area under the righting arm curve to the net-signed-area under the heeling arm curve between two specified angles, or area 'A' over area 'B' in the figure below.



- ResRatio:** the ratio of the residual areas between the heeling arm and righting arm curves. With the area between angle 'Ang1' and the angle of steady equilibrium defined as area 'A' (shown below) and the area between steady equilibrium and 'Ang2' defined as area 'B', the residual ratio is defined as the ratio of B/A.



- HybRatio:** the ratio of the reserve of dynamic stability to the total area under the righting arm curve between two user specified angles, or area 'A' over area 'A+B' in the figure below.



The second dropdown menu features two options, **'At'** and **'Between'**, which restrict the limits to either a single angle with 'At' or a range of angles with 'Between.' If one of these choices is inappropriate for the type of limit it will be removed from the list, such as 'at' with a ratio.

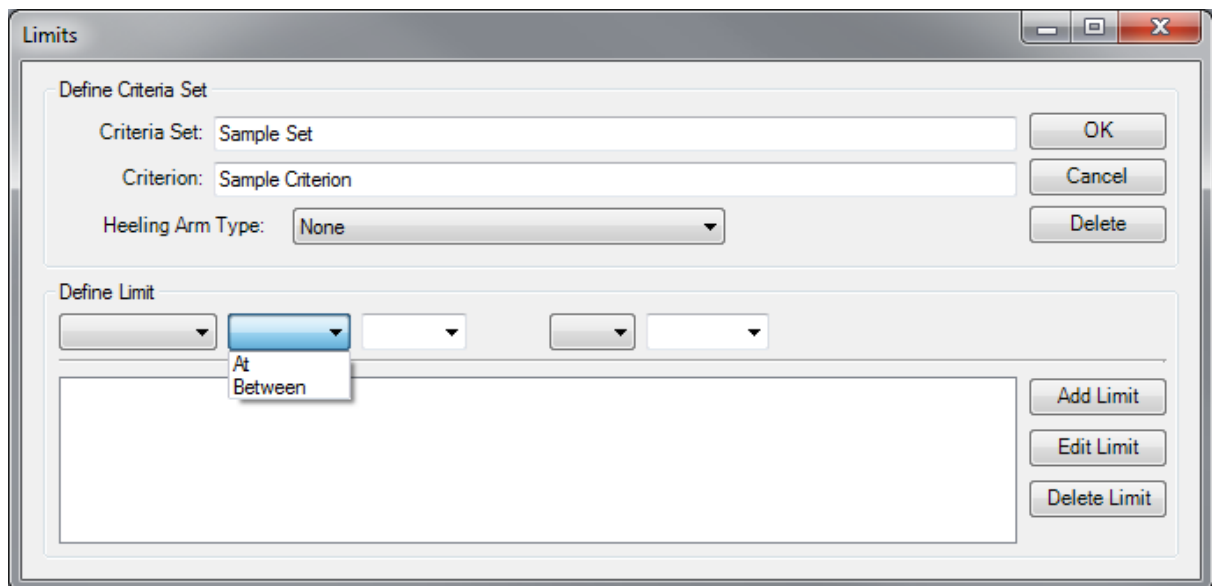


Figure 8: Limit Modifier

The third (and fourth if two angles are needed) dropdown contain the following options as well as manual entry of expressions and floating point numbers. In addition, any of the variables from the table at the end of this section which are appropriate may be used (note that they are case sensitive). It is possible to use just a number or a mixture of these angle names and numbers. For example entering 'FreeEquil – 15' would first find the angle associated with FreeEquil and subtract 15.

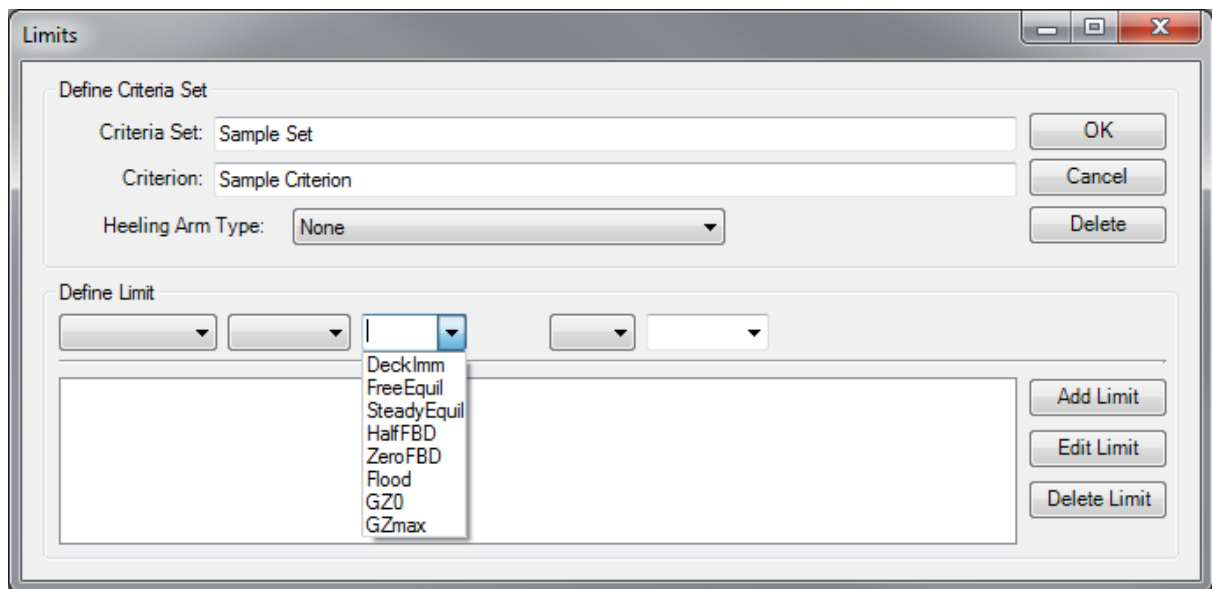


Figure 9: First Angle

- **DeckImm:** the angle at which any point on the deck becomes immersed
- **FreeEquil:** the angle at which the vessel reaches equilibrium in the absence of any heeling moment
- **SteadyEquil:** the angle at which the vessel reaches equilibrium between heeling moment and righting moment
- **HalfFBD:** the angle at which half of the freeboard (at free equilibrium) is gone.
- **ZeroFBD:** the angle at which all freeboard is gone (effectively the same angle as DeckImm)
- **Flood:** the angle at which the first downflood point becomes submerged
- **GZ0:** the angle at which the righting arm curve becomes negative, also known as the angle of vanishing stability or unsteady equilibrium
- **GZmax:** the angle of maximum righting arm

The next dropdown, shown below, allows for greater than (or equal to), less than(or equal to), equality, and inequality operators. The inequality operator is represented by '!='.

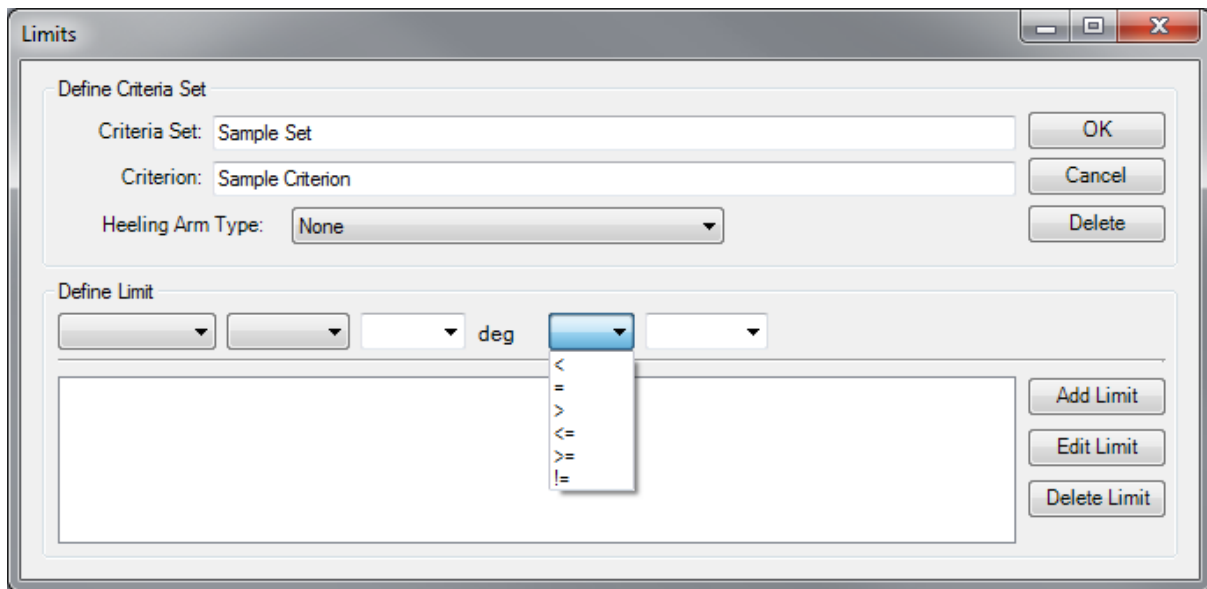


Figure 10: Limit Inequality

The last dropdown box features the same options and behavior as the angle dropdowns. Again, you may use expressions, floating point numbers, and any of the variables from the table at the end of this section which are appropriate (note that they are case sensitive).

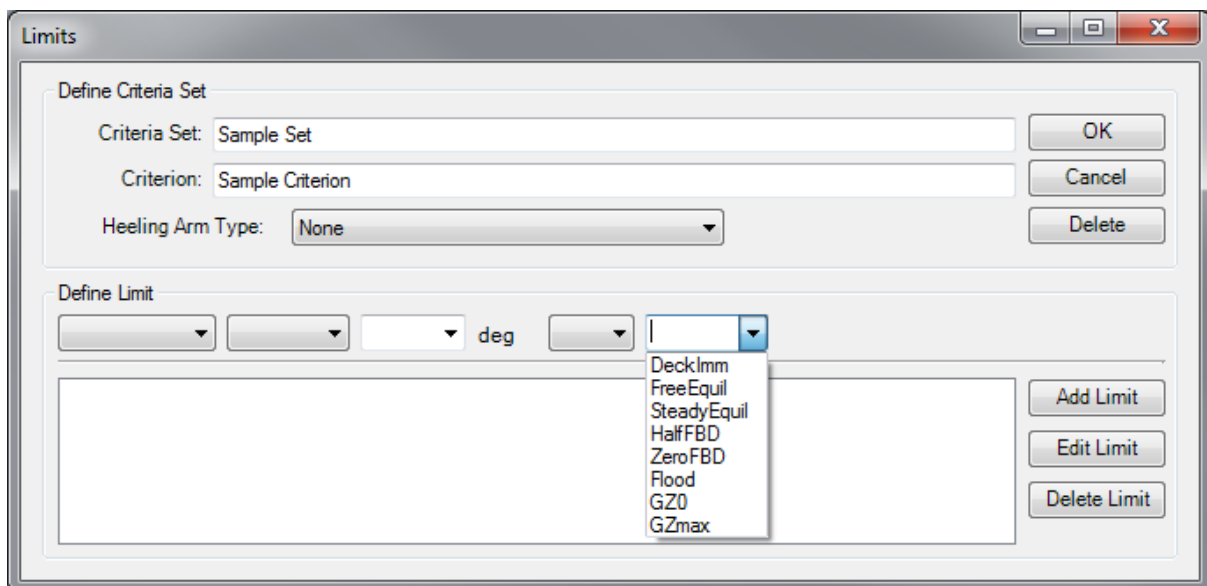


Figure 11: Limit Requirement

Once all selections have been made, the limit is not saved until 'Add Limit' is pressed.

The 'Limits' dialog box contains the following elements:

- Define Criteria Set:**
 - Criteria Set: Sample Set
 - Criterion: Sample Criterion
 - Heeling Arm Type: Wind
 - Buttons: OK, Cancel, Delete
- Define Limit:**
 - Angle Between SteadyEquil and DeckImm > 30 deg
 - Buttons: Add Limit, Edit Limit, Delete Limit

Figure 12: Limit Added

To edit a limit, select it and click 'Edit Limit.' This will populate the dropdowns and fields with the appropriate values and allow you to change them. Pressing 'Done' saves the changes.

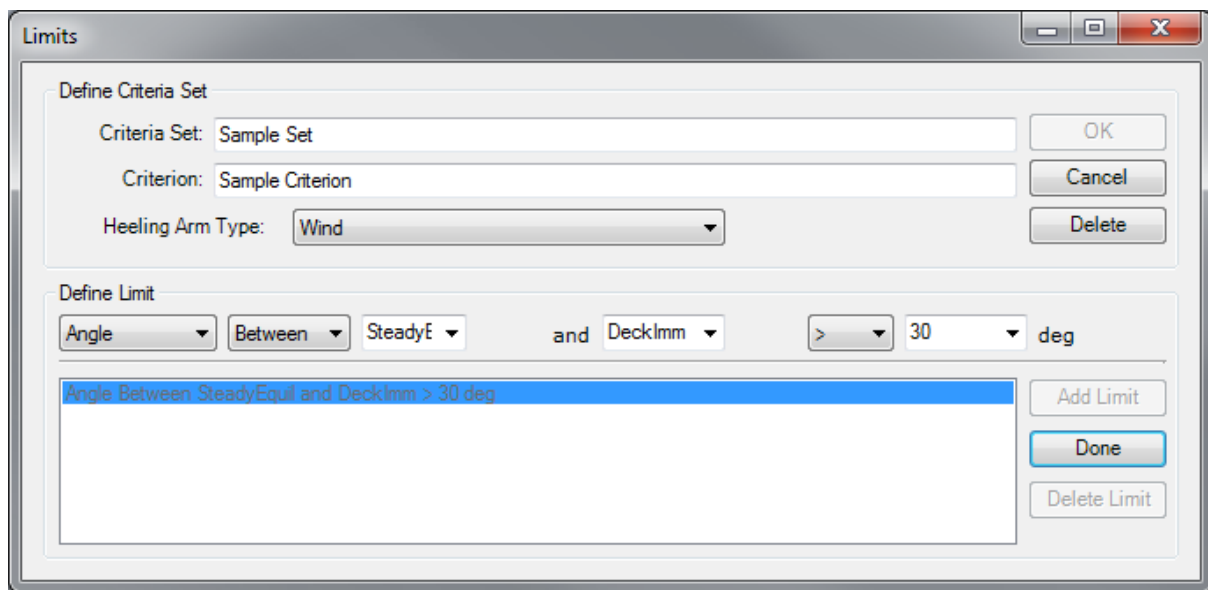


Figure 13: Editing a Limit

Example 1

If we wanted to require the GM to be greater than some height, say 0.2 meters, we would select GM from the first drop down. From the second dropdown, the only available option is 'At', which specifies what heel angle the constraint will be applied. In the third dropdown type '0' and notice that upon populating the fourth drop down 'deg' for degree appears denoting the angle. The fourth dropdown provides equalities, of which we will choose '>' for greater than. Lastly, enter '0.2' meters, which we have chosen as our initial GM requirement. Again, the limit we have just defined requires the initial GM to be greater than 0.2 meters. Now, click 'Add Limit' and you will see 'GM At 0 > 0.2 meters' populate the box of limits applying to the given criterion.

Example 2

Consider another limit where the intent is to require that, with a wind heeling arm, the residual ratio between 25 degrees before equilibrium and the lesser of deck immersion, flood, or 50 degrees to be greater than 1. This would require three limits where the only thing changing between them is the second angle. After the criterion is named, the heeling arm type should be set to 'Wind.' The first dropdown would be 'ResRatio,' second 'Between,' third 'Equil-25,' the next dropdown will be 'DeckImm' for one limit, 'Flood' for the second, and '50' for the last, and finally every limit will have '1' for the requirement.

Below is a table of the variables that are available for use when defining limits. Note that they are case sensitive.

Property	Description	Type
FluidDensity	Fluid density for the hydrostatics calculation	double
Displacement	The most recently computed displacement value.	double
TransverseMetacenter	Height of the transverse metacenter (measured from waterplane)	double
LongitudinalMetacenter	Height of the longitudinal metacenter (measured from waterplane)	double
MomentToTrim	Moment to change trim	double
WeightToImmerse	Weight to immerse	double
HeaveBoundaryConditionValue	Heave boundary condition value for hydrostatics calculation	double
ListBoundaryConditionValue	List boundary condition value for hydrostatics calculation	double
TrimBoundaryConditionValue	Trim boundary condition value for hydrostatics calculation	double
WaterplaneArea	The most recently computed waterplane area.	double
WetArea	The most recently computed wetted surface area.	double
LCB	The most recently computed longitudinal center of buoyancy in body coordinates.	double
TCB	The most recently computed transverse center of buoyancy in body coordinates.	double
VCB	The most recently computed vertical center of buoyancy in body coordinates.	double
It	The most recently computed transverse waterplane inertia.	double
I _l	The most recently computed longitudinal waterplane inertia.	double
BM _t	The most recently computed transverse BM.	double
BM _l	The most recently computed longitudinal BM.	double

List	The heel angle associated with the resultant free float condition in user units. This is defined as the angle between the body's transverse axis and the resultant flotation plane as per GHS. Its sign uses the Rhino positive sense based on the Rhino longitudinal axis	double
Trim	The trim angle associated with the resultant free float condition in user units. This is defined as the angle between the body's long'l axis and the resultant flotation plane as per GHS. Its sign uses the Rhino positive sense based on the Rhino transverse axis	double
Sinkage	Sinkage associated with the resultant free float condition at the origin.	double
Loa	The most recently computed overall length.	double
Boa	The most recently computed overall beam.	double
Depth	The most recently computed depth.	double
Lwl	The most recently computed waterline length.	double
Bwl	The most recently computed waterline beam.	double
Draft	The most recently computed draft.	double
Volume	The most recently computed volume.	double
LCF	The most recently computed longitudinal center of flotation in body coordinates.	double
TCF	The most recently computed transverse center of flotation in body coordinates.	double
VCF	The most recently computed vertical center of flotation in body coordinates.	double
Ax	The most recently computed maximum section area.	double
XAx	The most recently computed location of station of max section area.	double

TransverseRightingArm	Most recently computed transverse righting arm.	double
TransverseRightingMoment	The most recently computed transverse righting moment.	double
Cb	Block coefficient	double
Cwp	Waterplane coefficient	double
Cws	Wetted surface coefficient	double
Cp	Longitudinal prismatic coefficient	double
Cvp	Vertical prismatic coefficient	double
Cx	Maximum section coefficient	double
DLRatio	Displacement-length ratio; it is dimensional and in English units of long tons / ft ³	double
LCB_Lwl	Non-dimensional ratio LCB/Lwl measured from fwd end of waterline.	double
LCF_Lwl	Non-dimensional LCF/Lwl measured from fwd end of waterline.	double

11.5 Defining Heeling Arms

The options for Heeling Arm Type are Wind, Icing, Lifting, Pulling, Crowding, Turning, and Custom. For all heeling arm definitions, the user has three choices of computing the maximum value. The **‘Compute from Inputs (Above)’** radio button can be selected to compute the maximum heeling arm from the input parameters. Alternatively, the **‘Compute from Maximum Value:’** radio button can be selected to directly specify the maximum value of the heeling arm. A **‘Custom’** heeling arm may also be defined where the heeling arm curve is linearly interpolated between points.

Unlike the criterion, heeling arms are specific to each model. To apply a previously defined heeling arm to a new model, export the heeling arm from the source model to create an XML file which can then be imported to the target model.

Wind Heeling Arm Definition

The **‘Wind’** heeling arm definition box looks as the following, with entries for lateral projected area, lever arm, and nominal wind velocity. The lateral projected area is the area seen in a two dimensional profile view of the vessel above the waterline at the design draft. The lever arm is the half draft at the design load line plus the distance above the waterline to the centroid of the lateral projected area. The nominal wind velocity is a characteristic wind velocity.

The screenshot shows the 'New Heeling Arm Definition' dialog box. The 'Wind' tab is active. The 'Name' field is empty. The 'Lateral Projected Area' is input in m², 'Lever Arm' in m, and 'Nominal Wind Velocity' in kt. A diagram illustrates the vessel's cross-section with wind velocity V_w acting on the lateral area, the center of lateral area, draft T , and lever arm $T/2$. The 'Computation Method' section has three radio buttons: 'Compute from Inputs (Above)' (selected), 'Compute from maximum value' (with an input field in m), and 'Custom'. The 'Distribution' section has two radio buttons: 'Constant' and 'cos²' (selected). 'OK' and 'Cancel' buttons are at the bottom.

Figure 14: Wind Heeling Arm Definition

The heeling arm's shape can be controlled by the two radio buttons beneath 'Distribution'. With constant, the heeling arm will take a constant value of the heeling arm from the computation method. A \cos^2 distribution will give an always positive heeling arm of shape $\cos(\phi)^2$.

Wind with Ice Heeling Arm Definition

The wind with icing heeling condition takes the same inputs as the wind heeling arm definition with a few additional parameters; ice weight, ice height (from Rhino world origin), and ice longitudinal location. The ice height is the mass centroid of the ice above the Rhino world origin. The ice longitudinal location is the mass centroid relative to the Rhino world coordinate system. The same three computational methods exist as well as the constant or \cos^2 distributions.

New Heeling Arm Definition

Name:

Wind | Wind w/ Icing | Heavy Lifting | Towline Pulling | Deck Crowding | High-Speed Turn | Custom

Lateral Projected Area: m²

Wind Lever Arm: m

Nominal Wind Velocity: kt

Ice Weight: kgf

Ice Height (from origin): m

Ice Longitudinal Location: m

Diagram: Wind, V_w , Center of Lateral Area, Lever Arm, Ice Height, Draft, T , $T/2$

Computation Method

☒ Compute from Inputs (Above)

☐ Compute from maximum value: m

☐ Custom

Distribution

☐ Constant

☒ \cos^2

Cancel OK

Figure 15: Icing Heeling Arm Definition

Heavy Lifting Heeling Arm Definition

The heavy lift heeling arm definition takes the height of the lift from the Rhino world origin, the distance outboard from centerline, the longitudinal location of the weight, and the weight of the lift as parameters. The effect of the height, weight, and longitudinal location is to raise the VCG, change the LCG, and adjust the displacement. The weight and distance off centerline affect the heeling arm. The three computational methods are available as well as a constant distribution and a distribution that varies with the cosine of the angle of inclination. The dialogue looks like the following:

New Heeling Arm Definition

Name:

Wind Wind w/ Icing **Heavy Lifting** Towline Pulling Deck Crowding High-Speed Turn Custom

Height of Lift (from origin): m

Distance Off Center: m

Longitudinal Location: m

Weight of Lift: kgf

Diagram: A cross-section of a ship's hull is shown. A vertical dashed line represents the centerline. A weight 'W' is suspended at a height 'Height of Lift' from the centerline. The horizontal distance from the centerline to the weight is labeled 'Distance Off Center'.

Computation Method

☒ Compute from Inputs (Above)

☐ Compute from maximum value: m

☐ Custom

Distribution

☐ Constant

☒ cos

Cancel OK

Figure 16: Heavy Lifting Heeling Arm Definition

Towline Pulling Heeling Arm Definition

The towline pulling heeling arm definition has input parameters of number of propellers, propeller diameter, shaft horsepower, lever arm, and S fraction. The 'Shaft Horsepower' should be the power a single shaft is receiving. The lever arm is the vertical distance from the center of the propeller disk to the winch or windlass. The 'S fraction' is the decimal fraction of propeller slip stream effectively deflected by the rudder while the rudder is at a 45 degree angle. The three computational methods are available as well as a constant distribution and a distribution that varies with the cosine of the angle of inclination. The dialogue looks like the following:

New Heeling Arm Definition

Name:

Wind Wind w/ Icing Heavy Lifting **Towline Pulling** Deck Crowding High-Speed Turn Custom

Number of Propellers:

Propeller Diameter: m

Shaft Horsepower (ea): kW

Lever Arm: m

S Fraction:

Diagram: A cross-section of a ship's hull showing a propeller and a lever arm. Labels include 'Propeller Diameter' and 'Lever Arm'.

Computation Method

☒ Compute from Inputs (Above)

☐ Compute from maximum value: m

☐ Custom

Distribution

☐ Constant

☒ cos

Cancel OK

Figure 17: Towline Pulling Heeling Arm Definition

Deck Crowding Heeling Arm Definition

The deck crowding heeling arm definition takes two input parameters; lever arm and weight of personnel. The lever arm is the distance outboard from the centerline. In defining the heeling moment for crowding of personnel, it should be assumed that all personnel move as far outboard as possible on the main deck or any personnel deck above it. The three computational methods are available as well as a constant distribution and a distribution that varies with the cosine of the angle of inclination. The dialogue looks like the following:

New Heeling Arm Definition

Name:

Wind Wind w/ Icing Heavy Lifting Towline Pulling **Deck Crowding** High-Speed Turn Custom

Lever Arm: m

Weight of Personnel: kgf

Computation Method

- ☒ Compute from Inputs (Above)
- ☐ Compute from maximum value: m
- ☐ Custom

Distribution

- ☐ Constant
- ☒ cos

Cancel OK

Figure 18: Deck Crowding Heeling Arm Definition

High Speed Turn Heeling Arm Definition

The high speed turn heeling arm definition takes three input parameters; the lever arm, speed of turn, and radius of turn. The lever arm is the half draft plus the distance above the waterline to the VCG, or equivalently the VCG minus the half draft. The velocity provided should be the steady-state velocity in the turn and the radius should be one half of the tactical diameter. The three computational methods are available as well as a constant distribution and a distribution that varies with the cosine of the angle of inclination. The dialogue looks like the following:

New Heeling Arm Definition

Name:

Wind Wind w/ Icing Heavy Lifting Towline Pulling Deck Crowding **High-Speed Turn** Custom

Lever Arm: m

Speed of Turn: kt

Radius of Turn: m

Center of Gravity

Draft, T

Lever Arm

T/2

Computation Method

☒ Compute from Inputs (Above)

☐ Compute from maximum value: m

☐ Custom

Distribution

☐ Constant

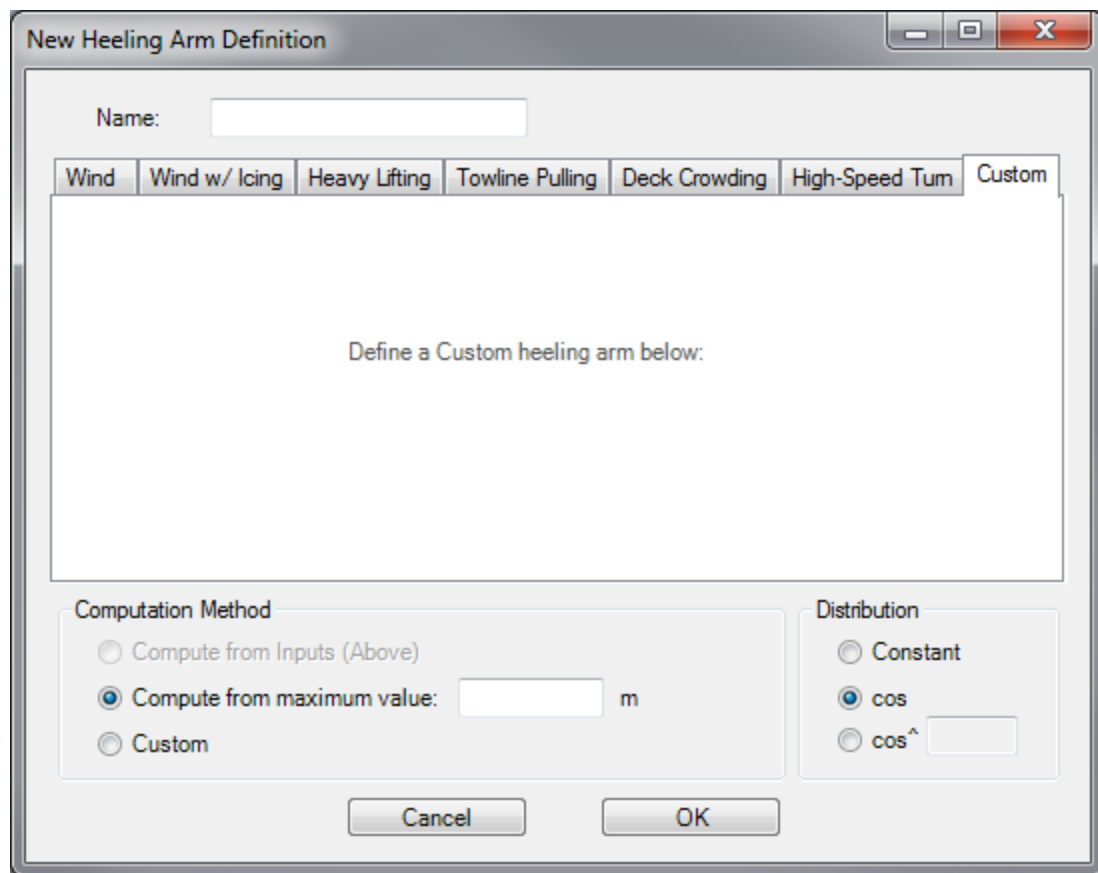
☒ cos

Cancel OK

Figure 19: High-Speed Turn Heeling Arm Definition

Custom Heeling Arm Definition

For a heeling arm that fits none of the other descriptions, the user has an option to create it under the '**Custom**' tab. The user can have a constant distribution, a cosine distribution, or $\cos^{\text{any power}}$ heeling arm distribution. Additionally, the linearly interpolated custom distribution can be entered. The dialogue looks like the following:

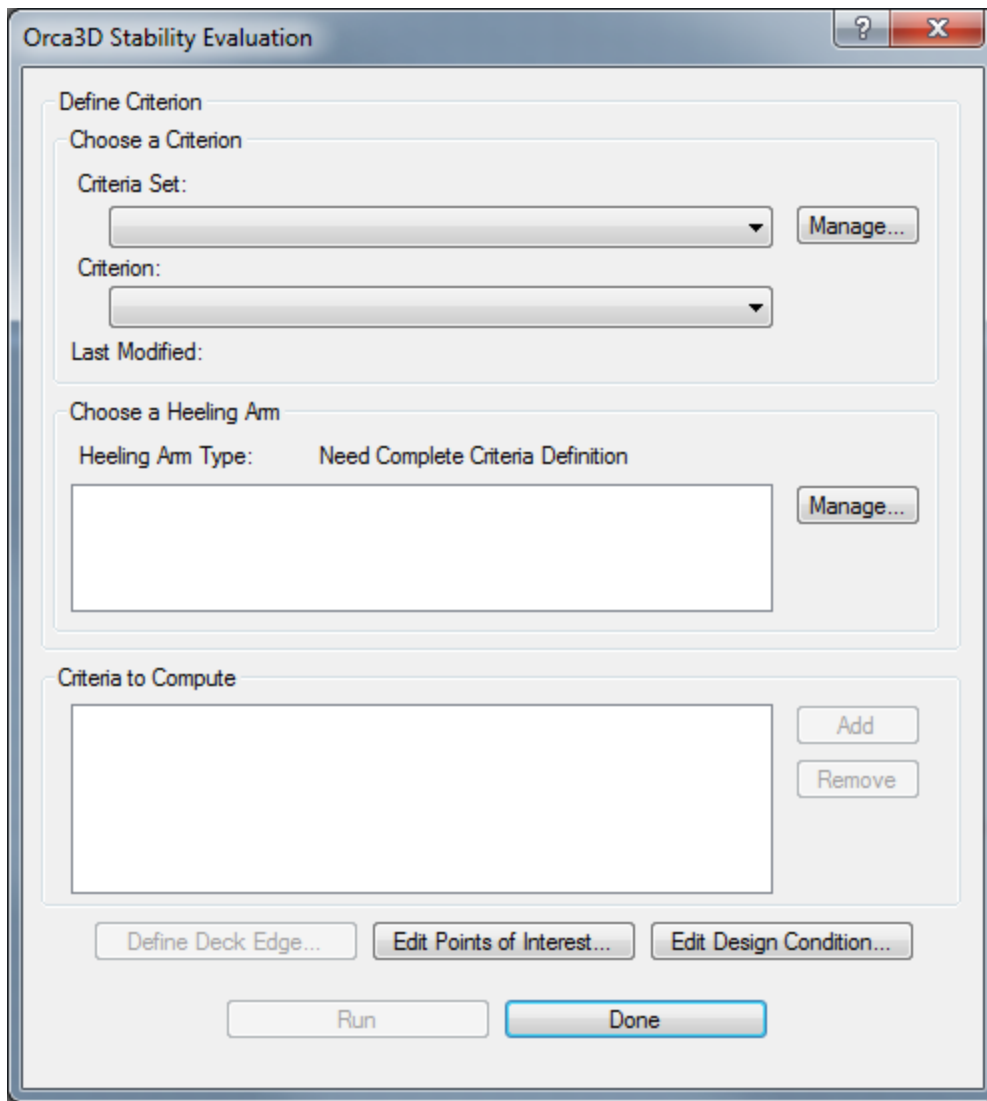


The image shows a software dialog box titled "New Heeling Arm Definition". At the top, there is a "Name:" label followed by a text input field. Below this is a row of seven tabs: "Wind", "Wind w/ Icing", "Heavy Lifting", "Towline Pulling", "Deck Crowding", "High-Speed Turn", and "Custom". The "Custom" tab is currently selected. The main area of the dialog is a large text box containing the text "Define a Custom heeling arm below:". At the bottom of the dialog, there are two sections. The "Computation Method" section has three radio buttons: "Compute from Inputs (Above)", "Compute from maximum value:" (which is selected and followed by a text input field and the unit "m"), and "Custom". The "Distribution" section has three radio buttons: "Constant", "cos" (which is selected), and "cos^" (followed by a text input field). At the very bottom are "Cancel" and "OK" buttons.

Figure 20: Custom Heeling Arm Definition

11.6 Selecting Criteria to Run

Use the '**Choose a Criterion**' section to pick your criteria set and individual criterion. Under the '**Choose a Heeling Arm**' section of the dialogue, define a heeling arm or import one. Check the heeling arms that you wish to be applied once they populate the dialogue box. To load the criterion, in the '**Criteria to Compute**' box click '**Add**'. You are now ready to run the stability evaluation by clicking 'Run' at the base of the dialogue box. By choosing 'Done', you will save your work but the stability evaluation will not run.



The image shows a software dialog box titled "Orca3D Stability Evaluation". It contains several sections for configuring stability analysis parameters.

Define Criterion

Choose a Criterion

Criteria Set: [Dropdown Menu] [Manage...]

Criterion: [Dropdown Menu]

Last Modified:

Choose a Heeling Arm

Heeling Arm Type: Need Complete Criteria Definition

[Empty List Box] [Manage...]

Criteria to Compute

[Empty List Box] [Add] [Remove]

[Define Deck Edge...] [Edit Points of Interest...] [Edit Design Condition...]

[Run] [Done]

Part

XII

12 Speed/Power Analysis

Orca3D contains methods for predicting the resistance of hulls. Two prediction methods are available - Savitsky (planing hulls) and Holtrop (displacement or semi-displacement hulls).

12.1 Overview

Orca3D Speed/Power Analysis

Orca3D Level 2 includes the capability to estimate speed/power performance using established empirical formulations that are well-suited for conceptual design. The current version of Orca3D incorporates two widely accepted resistance prediction methods. These include the Holtrop/Mennen prediction technique for designs operating in the displacement regime and the Savitsky prediction technique for designs operating in the planing regime. Both prediction methods are applicable to mono-hull designs, and it is important to recognize that the speed range and hull form characteristics of the vessel being analyzed must lie within the range of prediction parameters for which the methods are applicable in order to ensure confidence in the results. For a higher fidelity “first principles” based prediction of vessel resistance and powering performance that does not have these restrictions on hull form parameters, speed, or design features, Orca3D also offers a Computational Fluid Dynamics analysis system called Orca3D Marine CFD. Please refer to the Orca3D website at <https://orca3d.com/modules/orca3d-marine-cfd-simulation/> for additional information on the CFD module. For a more thorough propulsion analysis, you can [export the model to the NavCad software](#) from HydroComp, Inc.

The empirical prediction methods implemented in Orca3D are used to estimate the “bare hull” resistance of the design as a function of ship speed. To obtain the total resistance, additional drag effects should be considered including appendage drag, drag due to design features like propeller tunnels or bow thrusters, environmental drag from wind and waves, and any other contributions to drag. It is also common to add in a drag “margin” in early stage design to ensure there is sufficient power to reach the design speed. Orca3D accommodates these additional drag contributions through input of a “Resistance Design Margin” when performing the analysis. It is left to the user to estimate the cumulative effect of these factors, but useful information can be found in various publications such as “Principles of Naval Architecture”, “Resistance and Propulsion of Ships”, “Fluid Dynamic Drag”, and many other texts.

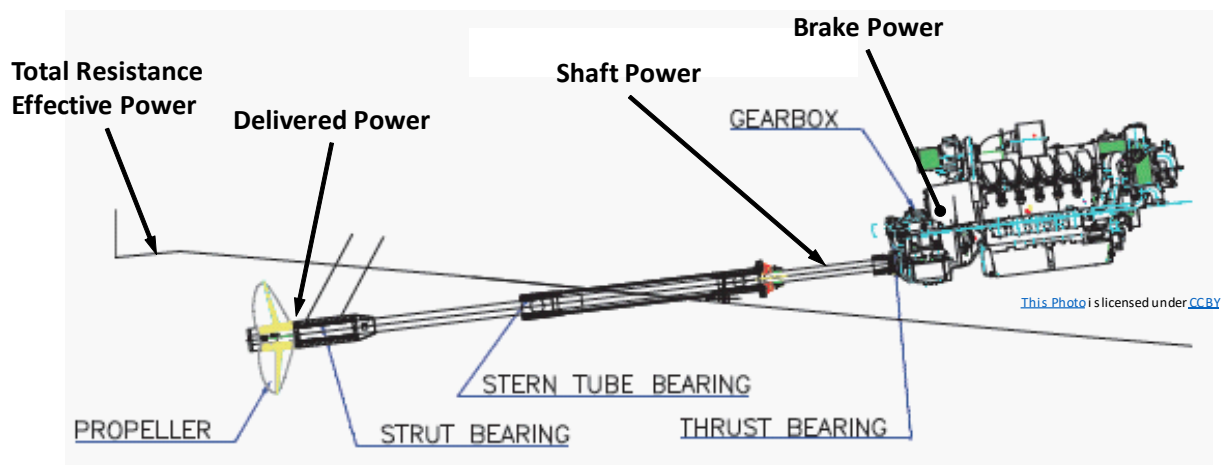
Once the total resistance has been estimated the power associated with this resistance can be determined as the product of the resistance and the speed of the ship. This resistance-based power is called the “Effective Power” defined as follows,

$$\text{Effective Power} = \text{Total Resistance} * \text{Vessel Speed}$$

It is important to recognize that the effective power is not the engine power required to propel the vessel at that speed. There are several additional factors that must be accounted for as shown in the figure below. The first of these factors involves the “losses” between the power associated with the total resistance and the power delivered to the propeller from the engine. These losses are typically cast as a combination of propeller open water efficiency (η_o) associated with the effectiveness of the propeller’s ability to convert torque into thrust, hull efficiency (η_H) associated with the flow field around the hull, and relative rotative efficiency (η_R) which accounts for the difference between the propeller in open water and that behind the hull. The cumulative effect of these phenomena results in an efficiency known as the propulsive coefficient which can be in the range of 0.45 to 0.70 depending on the design. Once the delivered power has been estimated, the shaft power can be determined by accounting for any bearing and torsional losses through the shaft line. This shaft efficiency (η_s) will of course depend on the number and types of shaft bearings used. Finally, the brake power at the engine is developed by accounting for any mechanical losses (η_M) in the connection between the shaft and engine, generally a result of transmission losses in the gearbox. In summary,

$$\text{Brake Power} = \text{Effective Power} / (\eta_o \cdot \eta_H \cdot \eta_R \cdot \eta_s \cdot \eta_M)$$

The product of efficiencies in the denominator of the equation above is sometimes referred to as the propulsive efficiency. Orca3D allows the user to enter a value for the overall propulsive efficiency so that the output propulsive power will reflect this efficiency. Refer to the following help topics for additional discussion on each of these methods as implemented in Orca3D.



1. E.V. Lewis, editor, “Principles of Naval Architecture”, Volume II Resistance, Propulsion, and Vibration, 1988.
2. Sv. Aa. Harvald, “Resistance and Propulsion of Ships”, 1983.
3. Hoerner, S.F. (1965) “Fluid-Dynamic Drag

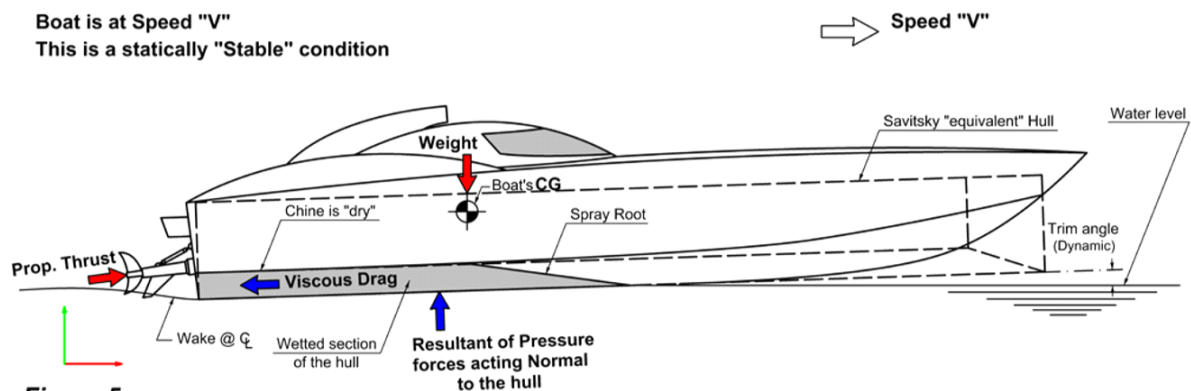
12.2 Planing Hull Savitsky Prediction

12.2.1 Introduction

Orca3D Planing Hull Prediction – Introduction

The Savitsky method, first widely published in a 1964 SNAME technical paper and then extended with addition information in 1976, can be considered a “semi-empirical” prediction method in that it applies a first principle physics analysis (albeit a static one) to determine the force and moment equilibrium condition but uses empirical relationships to estimate the forces and moments. The method simplifies the problem into a two-dimensional “static” approximation of the problem; that is, all forces are assumed to be lying in the vertical center-plane of the craft. For each speed to be analyzed, the method first makes an estimation of the dynamic forces acting over the hull, mainly friction and pressure forces (including magnitude, direction, and location) and, second, finds the equilibrium condition resulting from them along with the static weight and thrust forces.

In order to find the balance between the forces and moments, the hull is rotated (or “trimmed”) about a transverse axis to vary the angle of attack of the hull relative to the free surface and moved vertically to vary the wetted area. The lift and drag force magnitudes, directions, and the position in which they act vary as a function of the angle of attack and the wetted area, and the program iterates through various combinations until the balance between the forces and moments is achieved. This will result in the steady “Running Trim” angle. The figure below shows an example of the forces considered by this method for the most general case of analysis.



We can see here that, apart from craft's weight, the Savitsky method considers (in fact predicts) the resultant of the pressure forces acting normal to the hull bottom, the viscous drag acting along the hull's bottom (both of them acting within the wetted section of the hull), and it also considers the direction of the propulsion thrust, usually the shaft angle for the propeller thrust.

One important aspect of the Savitsky method to keep in mind is that the hull under analysis is not the actual “as-modeled” hull in Rhino. Instead, the Savitsky method assumes an equivalent prismatic V-type hull, with a constant deadrise angle and chine beam over the entire length of the hull. Even with this simplification the method is very reliable, if used for the analysis of similar hull types, i.e., single monohedral hulls with nearly constant deadrise extending, at least, over the wetted portion of the hull at running speed. However, the user must be careful to consider whether features in the design such as propeller tunnels or significant hull warp in the bottom surface will have a significant

effect on the predictions. There are several speed and hull parameter checks performed during the analysis with associated warning provided in the output if the checks fail.

Another important aspect relates to the implementation details of the Savitsky technique used in Orca3D. Although the published documents by Savitsky and others have been around for quite some time, there are several inputs to the calculation that are somewhat open to interpretation. For example, the deadrise angle for the prismatic hull forms used in Savitsky's model tests were constant and therefore easy to define. For real designs there will likely be a variation to the deadrise angle along the length of the hull. Where and how this deadrise angle is computed will clearly affect the results. Similarly, the chine beam is an important input parameter and for most hulls this value also depends where along the length it is measured. The Orca3D implementation uses recommendations derived from Blount's "Small-Craft Power Prediction" paper for these derived parameters.

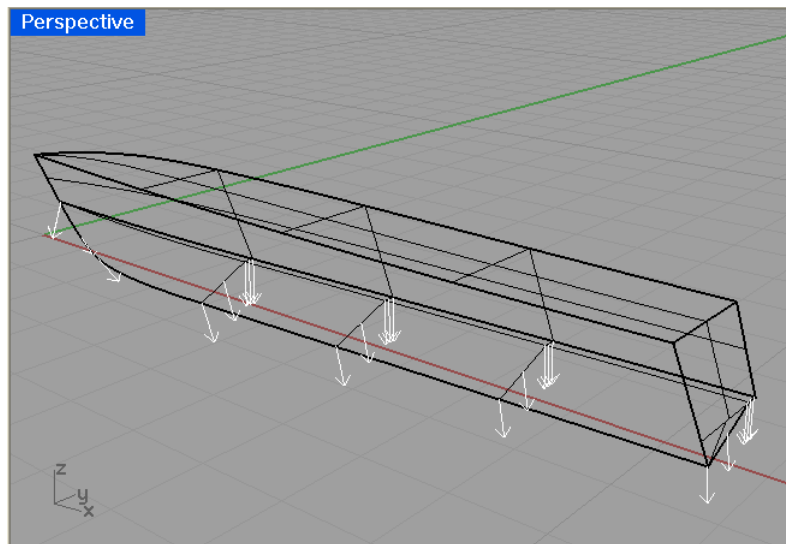
References

Savitsky, D., "Hydrodynamic Design of Planing Hulls", SNAME Marine Technology, Oct 1964.
Savitsky, D. & Brown, P.W., "Procedures for the Hydrodynamic Evaluation of Planing Hulls in Smooth and Rough Water", SNAME Marine Technology, Oct 1976.
Blount D.L. and Fox, D.L., "Small-Craft Power Prediction", SNAME Marine Technology, January 1976.


12.2.2 Model Requirements

It is critical to satisfy various requirements for the model when running the Planing Hull Savitsky Prediction. These are:

- Check the [Orca3D Properties](#) ⁷⁷ to be sure that the Model Orientation is correct (i.e., the Forward and Up directions are set properly)
- **MUST ONLY** represent the planing surface up to the chine; a hull surface that includes the topsides can be split at the chine by selecting the surface, then selecting the Surface menu > Surface Edit Tools > Split at Isocurve, finally selecting the curve representing the chine and press Enter
- **MUST ONLY** represent half of the hull
- **MUST** have a transverse coordinate of 0 on the centerline. For example, if you are analyzing a catamaran, you must move one half of the hull over so that the hull's centerline is at a transverse coordinate of 0.
- **MUST** have a surface normal direction pointing outward into the water. The surface normal direction can be verified by selecting the surface, then selecting *Direction* from the Rhino *Analyze* menu.



12.2.3 Computing Resistance

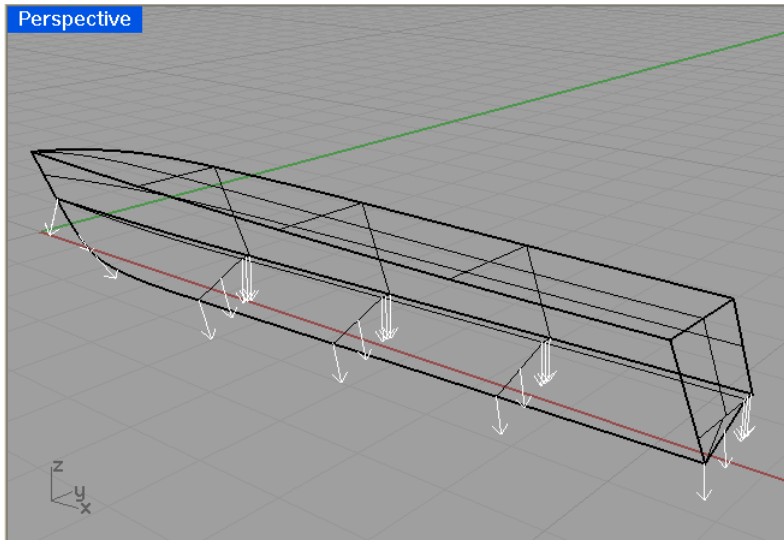
Toolbar	
Menu	Orca3D > Speed/Power > Planing Analysis
Command	OrcaPlaningAnalysis

Orca3D can compute the bare hull resistance of a planing hull for a user-defined range of speeds. The total predicted resistance, total effective power, and total propulsive power can then be calculated using a user-defined design margin and propulsive efficiency.

The process of computing the drag on a planing hull surface can be summarized as follows:

1. Select the planing surface or polysurface for the analysis. **Note: the selected surface or polysurface:**
 - **MUST ONLY** represent the planing surface up to the chine; a hull surface that includes the topsides can be split at the chine by selecting the surface, then selecting the Surface menu > Surface Edit Tools > Split at Isocurve, finally selecting the curve representing the chine and press Enter
 - **MUST ONLY** represent half of the hull
 - **MUST** have a transverse coordinate of 0 on the centerline (for example, a multi hull ship must be positioned so that the centerline is at Y=0, if Y is the transverse coordinate)

- **MUST have a surface normal direction pointing outward into the water.** The surface normal direction can be verified by selecting the surface, then selecting *Direction* from the Rhino *Analyze* menu.



2. Type the command: OrcaPlaningAnalysis, select Planing Analysis from the Orca3D menu, or select the Planing Hull Analysis icon from the Orca3D toolbar to initialize the planing analysis.
3. Input the following values into the Orca Planing Analysis dialog box:
 - Mass and geometry properties.
 - Range of vessel speeds (Note: the analysis will only give results for speeds providing a volumetric Froude number greater than 1.0).
 - Margins and efficiencies.
4. Select the OK button and the results will be displayed in report form in a separate window.

IMPORTANT: Select **ONLY** the planing surface to be included in the analysis. The program will use all surfaces selected in its calculations of deadrise angle, lift coefficient, effective beam, etc. If any other surfaces are selected, you will receive incorrect results.

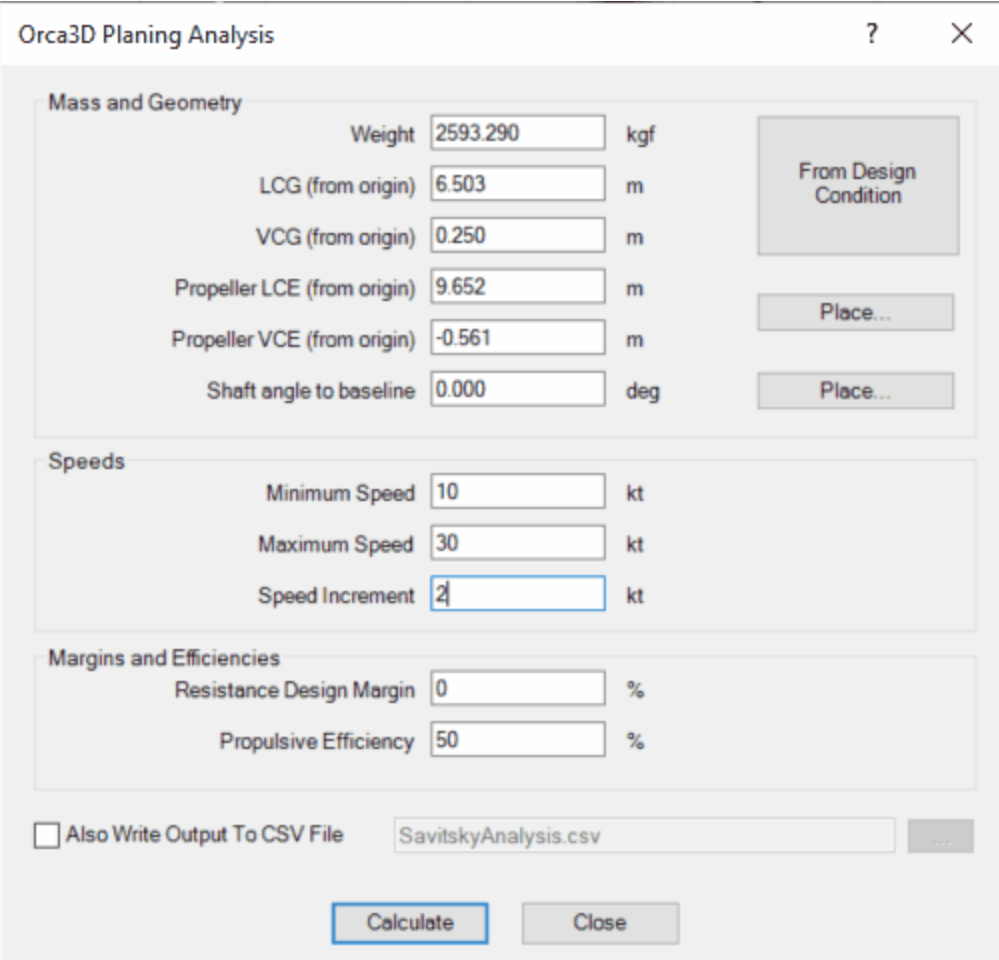
Splitting a Surface

A hull surface can be split at a specific curve, for instance the chine line, using Rhino surface edit tools. To split a surface, select the surface to be split, then select the Surface Menu > Surface Edit Tools > Split at Isocurve. Finally, select the curve to split the surface at and press Enter.

Note: the design condition must be redefined once the surface is split in order to use the calculated design condition values in the input dialog box.

Input Dialog

Once the planing analysis is started from the command line, Orca3D Menu, or Orca3D toolbar and the planing surface is selected, the Orca Planing Analysis dialog box will open.



The image shows the 'Orca3D Planing Analysis' dialog box. It has a title bar with a question mark and a close button. The dialog is divided into several sections: 'Mass and Geometry', 'Speeds', and 'Margins and Efficiencies'. In the 'Mass and Geometry' section, there are input fields for Weight (2593.290 kgf), LCG (from origin) (6.503 m), VCG (from origin) (0.250 m), Propeller LCE (from origin) (9.652 m), Propeller VCE (from origin) (-0.561 m), and Shaft angle to baseline (0.000 deg). To the right of these fields are buttons: 'From Design Condition' (a large button), 'Place...' (two buttons). The 'Speeds' section has input fields for Minimum Speed (10 kt), Maximum Speed (30 kt), and Speed Increment (2 kt). The 'Margins and Efficiencies' section has input fields for Resistance Design Margin (0 %) and Propulsive Efficiency (50 %). At the bottom, there is a checkbox 'Also Write Output To CSV File' and a text field 'SavitskyAnalysis.csv'. At the very bottom are 'Calculate' and 'Close' buttons.

Section	Parameter	Value	Unit
Mass and Geometry	Weight	2593.290	kgf
	LCG (from origin)	6.503	m
	VCG (from origin)	0.250	m
	Propeller LCE (from origin)	9.652	m
	Propeller VCE (from origin)	-0.561	m
	Shaft angle to baseline	0.000	deg
Speeds	Minimum Speed	10	kt
	Maximum Speed	30	kt
	Speed Increment	2	kt
Margins and Efficiencies	Resistance Design Margin	0	%
	Propulsive Efficiency	50	%

Also Write Output To CSV File: ☐ SavitskyAnalysis.csv

Buttons: Calculate, Close

Mass and Geometry

Weight: the weight of the vessel at the desired condition, in the units specified.

LCG (from origin): the longitudinal center of gravity of the vessel measured from the world origin in the units specified.

VCG (from origin): the vertical center of gravity of the vessel measured from the world origin in the units specified.

Note: the weight, LCG, and VCG can be automatically filled in by Orca3D if a design

condition is specified after the planing surface is split (if necessary) from the hull surface by clicking the *From Design Condition* box.

Propeller LCE (from origin): the longitudinal center of effort of the propeller measured from the world origin in the units specified.

Propeller VCE (from origin): the vertical center of effort of the propeller measured from the world origin in the units specified.

Shaft angle to baseline: the angle from the propeller shaft to the baseline, measured in the units specified.

Note: these values can be specified on the model by clicking the corresponding *Place...* button next to each input box.

Speeds

Enter the minimum speed, maximum speed, and speed increment in the units specified for this analysis.

Note: the analysis will only give results for speeds providing a volumetric Froude number greater than 1.0.

Margins and Efficiencies

Resistance Design Margin: the margin added to the bare hull resistance to calculate total resistance and effective power. This margin can be used to account for appendages, wind, waves, shallow water, etc.

Propulsive Efficiency: the ratio of effective power to propulsive power. This efficiency can be used to account for losses in the propeller, shafting, transmission, etc and will thus determine the true definition of total propulsive power.

Also write to CSV File

If this box is checked, the results of the analysis will be written to the csv file that you specify. This text file can be read directly into Excel.

12.2.4 Output

After clicking OK in the Planing Analysis dialog box, a separate report window will open with the planing hull analysis results providing the following output values:

Prediction Parameters

Method: an enhanced version of the Savitsky general case method for resistance calculations of a planing hull.

SpeedCheck: Confirmation that your range of speeds is within the valid minimum and maximum values, based on FnBch (Froude number, based on effective planing beam).

HullCheck: This is a summary of the checks on the parameters of deadrise angle, LCG location, and lift coefficient. If any of these are outside of the valid range, it will be flagged here. Each of these parameters is listed individually below in the Parameter Check section.

DesignMarginPercent: the user-defined margin used to account for the differences in the current model and the final design. This can also be used to account for loss of efficiency due to wind, waves, appendages, shallow water, etc.

WaterType: the type of water used in the planing analysis. This can be changed in the Orca3D Properties dialog box.

WaterDensity: the density of the water used in the planing analysis in the units specified. This can be changed in the Orca3D Properties dialog box.

WaterViscosity: the viscosity of the water used in the planing analysis in the units specified.

RoughAllowance: Standard Roughness Allowance

Propulsive Efficiency: the user-defined propulsive efficiency used in the analysis.

Vessel Data

This section provides calculated and user-defined values defining the planing surface and vessel being analyzed.

MaxPlaningLength: the calculated overall length of the planing surface.

MaxPlaningBeam: the calculated overall beam of the planing surface.

DisplacementBare: the user-defined bare hull displacement in the units specified.

LCGFwdTransom: the user-defined longitudinal center of gravity measured from the transom in the units specified.

VCGAboveBL: the user-defined vertical center of gravity measured from the baseline in the units specified.

ShaftAngle: the user-defined propeller shaft angle in degrees relative to the

baseline.

LCEFwdTransom: the longitudinal center of effort of the propeller measured from the transom in the units specified.

VCEAboveBL: the vertical center of effort of the propeller measured from the baseline in the units specified.

Parameter Check

This section verifies the following calculated parameters are within a defined range to ensure accurate results.

LCGBchRatio: the ratio of the longitudinal center of gravity forward of the transom to the maximum planing beam.

FnBchMax: the maximum calculated Froude number based on the maximum planing beam at the design speed.

DeadriseMidLen: the angle of deadrise at the mid-length of the planing surface.

CLBmax: the maximum value of the lift coefficient for the wetted planing area at the maximum speed.

Results Tables

The two tables provide the following results for each of the user-defined speeds:

Fnv: the volumetric Froude number for the corresponding speed defined as $F_{nv} = \text{Speed} / (g * \text{DisplacedVolume}^{1/3})^{1/2}$

Trim (deg): the predicted trim of the vessel at the corresponding speed. This value is difficult to relate directly to your model, as it is relative to the keel of the "equivalent prismatic hull" that is used in the Savitsky method. One interpretation is that it is the trim relative to the water surface of the 1/4 buttock line at the mean wetted length position (reference "The Effect of Bottom Warp on the Performance of Planing Hulls" by Daniel Savitsky, The Third Chesapeake Power Boat Symposium, Annapolis, MD June, 2012). Also read more detail at <https://cdn.shopify.com/s/files/1/0258/9989/2790/files/Orca3DStaticvsDynamicTrim.pdf?v=1577996250>

Rbare (N): the predicted bare hull resistance at the corresponding speed.

Rtotal (N): the total predicted resistance including the user-defined design margin at the corresponding speed.

PEtotal (W): the calculated total effective power of the vessel including the design margin at the corresponding speed.

PPtotal (W): the calculated total propulsive power of the vessel dependent on the

user-defined propulsive efficiency. For example:

Propulsive Efficiency Input	Propulsive Power Output
Quasi-propulsive efficiency	Delivered Power
Overall efficiency including gearing losses	Brake Power

PP_{total} is defined as the total effective power divided by the propulsive efficiency and will be representative of the power defined by the propulsive efficiency input.

Fn_{Bch} : the Froude number calculated using the effective planing beam at the corresponding speed.

Eff Planing Beam: the calculated effective planing beam of the wetted planing area. The effective planing beam is computed for each speed from the geometry defining the planing surface. One important consideration when using the Savitsky method is that it was developed for prismatic hulls, meaning that the hull is a prism of a pure wedge shape. These hulls had linear sections from keel to chine with constant deadrise (no warp), and no strakes or rails.

Eff Deadrise (deg): the calculated effective angle of deadrise of the wetted planing area.

R_{bare}/W : the ratio of the predicted bare hull resistance to the bare hull weight at the corresponding speed.

Porpoising: (Longitudinal dynamic instability) The projected porpoising stability of the vessel: Stable, Unstable or Check. Orca3D provides a prediction of the likelihood of longitudinal dynamic instability (more commonly known as "porpoising"). Porpoising is a complex coupling of heave and pitch that are dependent on a variety of hull properties, such as loading, speed and LCG position. It is critical to evaluate the possibility of porpoising during early design stages. Two different evaluation algorithms are used in Orca3D [Savitsky, 1976¹][Celano, 1998²]. The well-known Savitsky algorithm is based on a limiting "critical trim" indicator, as is the Celano algorithm (an implementation of earlier work [Day, 1952³]). Orca3D evaluates both indicators and presents the likelihood of porpoising as Stable (neither indicate porpoising), Check (one indicates porpoising), or Unstable (both indicate porpoising).

Prediction Check: at each speed the predicted condition of the vessel is checked against known valid ranges for the Savitsky method. The output is either OK, or specifies "Check=" followed by the number 1 through 4. The report provides the definition of each type of warning under the Prediction Checks section. We caution against using results where a prediction warning is found.

Results Plots

The last page of the report provides plots of bare and total hull resistance versus speed, total effective power and total propulsive power versus speed, and trim angle versus speed.

¹Savitsky, D. and Brown, P.W., "Procedures for the Hydrodynamic Evaluation of Planing Hulls in Smooth and Rough Waters," Marine Technology, Vol. 13, No. 4, October 1976.

²Celano, T., "The Prediction of Porpoising Inception for Modern Planing Craft," SNAME Transactions, 1998.

³Day, J.P. and Haag, R.J., "Planing Boat Porpoising," Thesis, Webb Institute of Naval Architecture, 1952.

12.3 Displacement Hull Holtrop Prediction

12.3.1 Introduction

The method of Holtrop and Mennen, applicable to hull forms operating in displacement mode, has been published in several technical papers with refinements made over the years. It is widely used during the concept design phase due to its robustness and the breadth of its underlying hull form database. The basis for the Orca3D implementation is obtained from papers from 1978, 1982, and 1984. The method is a statistical regression of model tests, most conducted at MARIN, and full-scale trial measurements totaling 334 models against about a dozen hull parameters. The method predicts the total ship resistance, R_T as:

$$R_T = R_F (1 + k) + R_W + R_B + R_{TR} + R_{APP} + R_A$$

where,

R_F = ITTC flat plate frictional resistance

$1+k$ = hull form factor

R_W = wave-making resistance

R_B = additional pressure resistance of bulbous bow near the water surface

R_{TR} = additional pressure resistance due to transom immersion

R_{APP} = appendage resistance

R_A = model-ship correlation resistance

In the current Orca3D implementation the appendage resistance is not explicitly included, and it is expected that the end user will incorporate appendage resistance into the input resistance margin value. Estimation of the other resistance components and factors come from the input and derived hull form parameters, which can be seen in the Orca3D displacement hull form calculation dialog.

As with other empirical prediction methods, it is important to ensure that the hull form characteristics of the design being analyzed are within the range of the database of models used to develop the regression equation. Orca3D performs a check on these parameters and reports any


exceedance in the output. In addition, some of the derived hull form parameters are not well-defined and can result in differences between different implementations of the Holtrop and Mennen methods for the same design. In particular, the stern shape coefficient described by Holtrop is somewhat nebulous in its description when applied to actual ship designs. Although more well understood, the half entrance angle of the waterline and the immersed transom area can have different values depending on how they are computed. For example, the longitudinal location at which the entrance angle is computed can significantly affect its value, and ships with immersed transoms that have a negative rake angle can lead to questions about what the “effective” transom area is. Orca3D attempts to apply algorithms providing a consistent behavior regarding the evaluation of these parameters. It is recommended that the user pay close attention to the computed values to ensure that they reasonably represent the design.

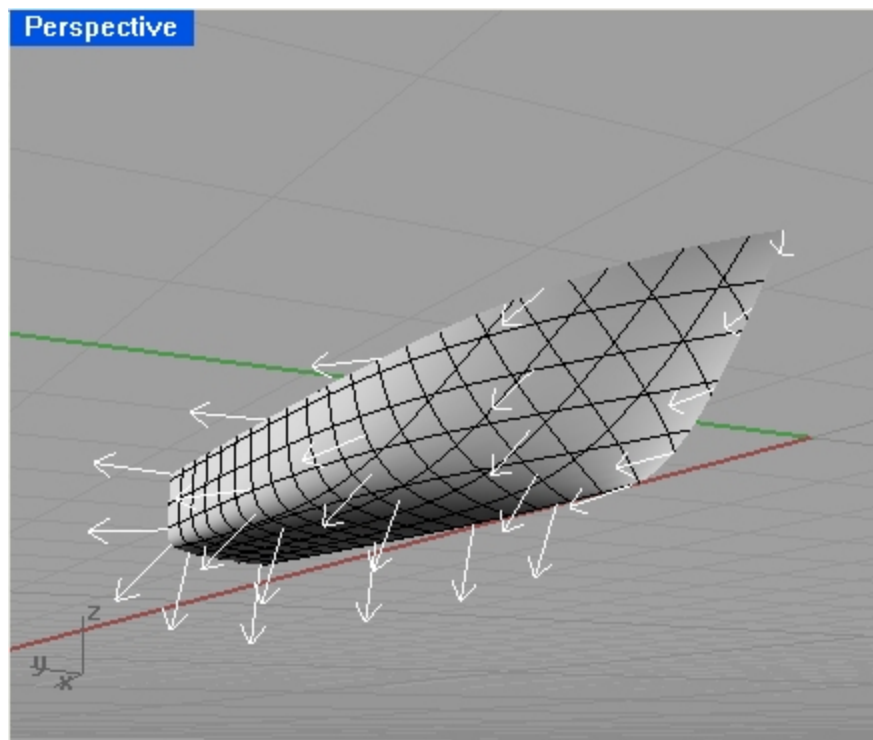
References

- Holtrop, J. and Mennen, G.G.J., “A Statistical Power Prediction Method”, International Shipbuilding Progress, Vol. 25, October 1978.
Holtrop, J. and Mennen, G.G.J., “An Approximate Power Prediction Method”, International Shipbuilding Progress, Vol. 29, July 1982.
Holtrop, J., “A Statistical Re-Analysis of Resistance and Propulsion Data”, International Shipbuilding Progress, Vol. 31, November 1984.


12.3.2 Model Requirements

It is critical to satisfy various requirements for the model when running the Displacement Hull Holtrop Prediction. These are:

- Check the [Orca3D Properties](#)  to be sure that the Model Orientation is correct (i.e., the Forward and Up directions are set properly)
- **MUST ONLY** select external hull surfaces that are “wet” at the static waterline for which the analysis is being performed. Do not include appendages such as rudders.
- **MUST ONLY** represent half of the hull
- **MUST** have a transverse coordinate of 0 on the centerline
- Integrated skegs may be included as part of the hull
- **MUST** have a surface normal direction pointing outward into the water. The surface normal direction can be verified by selecting the surface, then selecting *Direction* from the *Rhino Analyze* menu.



12.3.3 Computing Resistance

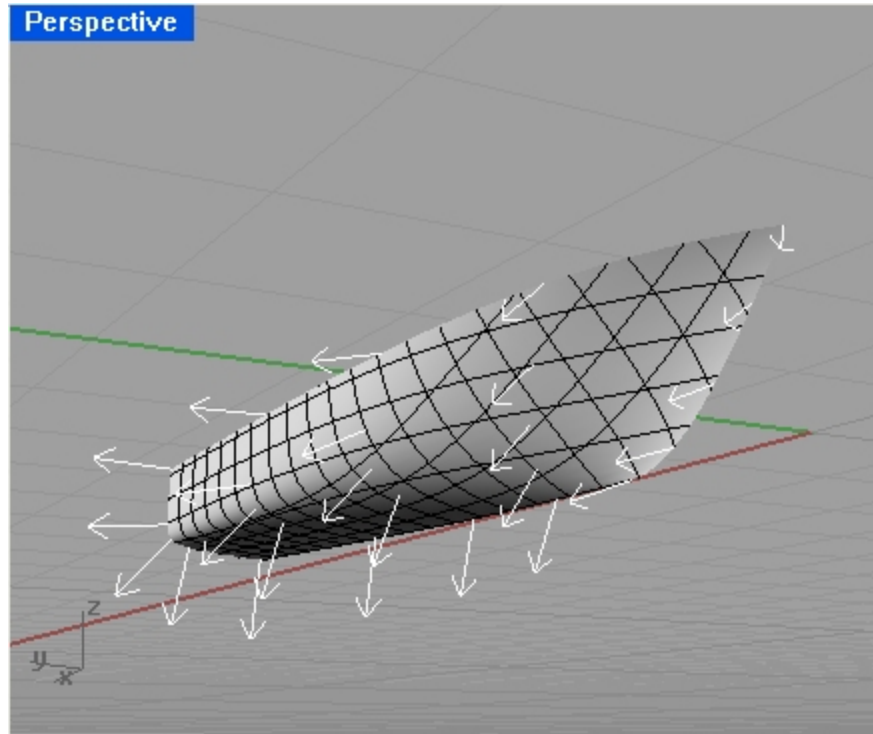
Toolbar	
Menu	Orca3D > Speed/Power > Holtrop Analysis
Command	OrcaHoltropAnalysis

Orca3D can compute the bare hull resistance of a displacement hull for a user-defined range of speeds. The total predicted resistance, total effective power, and total propulsive power can then be calculated using a user-defined design margin and propulsive efficiency.

The process of computing the drag on a displacement hull surface can be summarized as follows:

1. Select the planing surface or polysurface for the analysis. **Note: the selected surface or polysurface:**
 - **MUST ONLY** select external hull surfaces that are “wet” at the static waterline for which the analysis is being performed. Do not include appendages such as rudders.
 - **MUST ONLY** represent half of the hull
 -

- **MUST have a transverse coordinate of 0 on the centerline** (for example, a multi hull ship must be positioned so that the centerline is at $Y=0$, if Y is the transverse coordinate)
- **Integrated skegs may be included as part of the hull surface**
-
- **MUST have a surface normal direction pointing outward into the water.** The surface normal direction can be verified by selecting the surface, then selecting *Direction* from the *Rhino Analyze* menu.



2. Type the command: OrcaHoltropAnalysis, select Holtrop Analysis from the Orca3D menu, or select the Holtrop Analysis icon from the Orca3D toolbar to initialize the analysis.
3. Input the following values into the Holtrop Speed/Power Analysis dialog box:
 - Mass and geometry properties.
 - Range of vessel speeds.
 - Margins and efficiencies.
4. Select the OK button and the results will be displayed in report form in a separate window.

IMPORTANT: Select ONLY the external hull surface(s) to be included in the analysis. The program will use all surfaces selected in its calculations of various parameters. If any other surfaces are selected, you will receive incorrect results.

Input Dialog

Once the Holtrop analysis is started from the command line, Orca3D Menu, or Orca3D toolbar and the surface is selected, the Holtrop Speed/Power Analysis dialog box will open. If you have a [Design Condition](#)^[270] already defined, it will be used as the Mass/Geometry source, and most of the input fields will be completed automatically. You will only need to input the desired speed range and increment, and specify your Correlation Allowance, Resistance Design Margin, and Propulsive Efficiency. For the Correlation Allowance you may choose from the method defined in the Holtrop method or the ITTC78 method.

Holtrop Speed/Power Analysis

Mass and Geometry

Displacement	19086047.736	kgf	Awp	2914.467	m ²
LCB (% fwd midships)	0.047	%	Wetted Surface	4370.180	m ²
Lwl	152.463	m	Ax	190.861	m ²
Bwl	24.979	m	Transom Area	0.002	m ²
Tx	8.000	m	ABulb	0.000	m ²
Half Entry Angle	12.476	deg	ZBulb (below WL)	0.000	m
Stern Coefficient	-18.358				

Speeds

Minimum Speed	8	kt
Maximum Speed	18	kt
Speed Increment	2	kt

Margins and Efficiencies

Correlation Allowance, Ca	0.000426	
Resistance Design Margin	0.000	%
Propulsive Efficiency	50.000	%

Mass and Geometry Source

Mass/Geometry from: Design Hydrostatics An

☐ Also Write Output To CSV File

HoltropAnalysis.csv

Calculate Close

If you have not already defined the Design Condition, you will be prompted to do so. If you don't want to, the dialog will open, but now the Mass/Geometry source will be "Manual Override." Also, even if you do have a Design Condition, you can always switch to Manual Override to change any of the Mass and Geometry parameters:

Holtrop Speed/Power Analysis ? X

Mass and Geometry

Displacement	19086047.736	kgf	Awp	2914.467	m ²
LCB (% fwd midships)	0.047	%	Wetted Surface	4370.180	m ²
Lwl	152.463	m	Ax	190.861	m ²
Bwl	24.979	m	Transom Area	0.002	m ²
Tx	8.000	m	ABulb	0.000	m ²
Half Entry Angle	12.476	deg	ZBulb (below WL)	0.000	m
Stern Coefficient	-18.358				

Speeds

Minimum Speed	8.000	kt
Maximum Speed	18.000	kt
Speed Increment	2.000	kt

Margins and Efficiencies

Correlation Allowance, Ca	0.000426	▼
Resistance Design Margin	0.000	%
Propulsive Efficiency	50.000	%

Mass and Geometry Source

Mass/Geometry from: Manual Override ▼

☐ Also Write Output To CSV File

HoltropAnalysis.csv ...

Calculate Close

Once you have entered all of the parameters, click OK to run the analysis. The [output data](#) will then be presented in the Report Viewer.

Mass and Geometry

Displacement: the weight of the vessel at the desired condition, in the units specified.

LCG (% fwd midships): distance of the LCG forward of the mid-LWL point, as a percentage of LWL

LWL: The length of the waterline at the desired condition

BWL: Waterline beam at the desired condition.

Tx: Draft at the station of maximum area at the desired condition.

Half Entrance Angle: The angle between the design waterline and the centerline in planview at the desired condition

Stern Coefficient: A coefficient used to describe the cross-sectional shape of the afterbody. It is used in the prediction of form factor and wake fraction.

Extreme V-shaped buttock-flow (such as barges) = -25 to -20

V-shaped buttock-flow = -10

Normal diagonal-flow = 0

U-shaped waterline-flow = 10

AWP: Area of the waterplane at the desired condition

Wetted Surface: Wetted surface area of the hull at the desired condition. Transom area should not be included in this value.

Ax: Area of the station of maximum wetted cross-sectional area at the desired condition

Transom Area: The area of the submerged portion of the transom

ABulb: Cross-sectional area of the bulb at the forward end of the waterline

ZBulb: The distance of the centroid of the bulb area below the waterline, at the forward end of the waterline

Speeds

Enter the minimum speed, maximum speed, and speed increment in the units specified for this analysis.

Margins and Efficiencies (see [Overview](#) ³⁴⁸)

Correlation Allowance: an allowance used to account for differences in extrapolation methods, hull roughness, and scale effects.

Resistance Design Margin: the margin added to the bare hull resistance to calculate total resistance and effective power. This margin can be used to account for appendages, wind, waves, shallow water, etc.

Propulsive Efficiency: the ratio of effective power to propulsive power. This efficiency can be used to account for losses in the propeller, shafting, transmission, etc and will thus determine the true definition of total propulsive power.

12.3.4 Output

After clicking OK in the Holtrop Speed/Power Analysis dialog box, a separate report window will open with the displacement hull analysis results providing the following output values:

Prediction Parameters

Method: a modified version of the 1984 Holtrop analysis.

SpeedCheck: a check of the extents of the entered speeds by comparing it to the minimum and maximum FnBch range.

HullCheck: a check of deadrise angle, LCG/Bch ratio, and CLb to be sure that they fall within appropriate ranges.

DesignMarginPercent: the user-defined margin used to account for the differences in the current model and the final design. This can also be used to account for loss of efficiency due to wind, waves, appendages, shallow water, etc.

WaterType: the type of water used in the displacement hull analysis. This can be changed in the Orca3D Properties dialog box.

WaterDensity: the density of the water used in the displacement hull analysis in the units specified. This can be changed in the Orca3D Properties dialog box.

WaterViscosity: the viscosity of the water used in the displacement hull analysis in the units specified.

FormFactor: the factor that accounts for the three-dimensional effects of the hull shape and appendages.

CorrAllowance: an allowance used to account for differences in extrapolation methods, hull roughness, and scale effects.

Propulsive Efficiency: the user-defined propulsive efficiency used in the analysis.

Vessel Data

This section provides calculated and user-defined values defining the displacement hull being analyzed.

LengthWL: the waterline length of the displacement hull in the units specified.

BeamWL: the waterline beam of the displacement hull in the units specified.

MaxMoldedDraft: the maximum molded draft of the displacement hull in the units specified.

DisplacementBare: the user-defined bare hull displacement in the units specified.

WettedSurface: the wetted surface area of the displacement hull in the units specified.

MaxSectionArea: the maximum sectional area value for the displacement hull in the units specified.

WaterplaneArea: the waterplane area of the displacement hull at its defined condition in the units specified.

LCG (% fwd midships): distance of the LCG forward of the mid-LWL point, as a percentage of LWL

BulbAreaAtFP: the area of the bulbous bow at the forward perpendicular in the units specified, if applicable.

BulbCentroidBelowWL: the distance to the centroid of the bulb measured from the defined waterline in the units specified, if applicable.

TransomArea: the area of the transom of the displacement hull in the units specified.

HalfEntranceAngle: the half-angle of entrance of the load waterline.

SternTypeCoef: the stern type coefficient accounting for the specific shape of the afterbody.

Parameter Check

This section verifies the following calculated parameters are within a defined range to ensure accurate results.

PrismaticCoef: the calculated prismatic coefficient of the displacement hull.

LwlBwlRatio: the ratio of the waterline length to the beam at the waterline.

LambdaCoef: the mean wetted length to wetted beam ratio of the hull.

BwlDraftRatio: the ratio of the beam at the waterline to the defined vessel draft.

Results Tables

The two tables provide the following results for each of the user-defined speeds:

Fn: the calculated Froude number using the waterline length and the corresponding speed.

Cf (x 1000): the frictional resistance coefficient at the corresponding speed multiplied by 1000.

Cr (x1000): the residuary resistance coefficient at the corresponding speed multiplied by 1000.

Rbare (N): the predicted bare hull resistance at the corresponding speed.

PEtotal (W): the calculated total effective power of the vessel including the design margin at the corresponding speed.

Rtotal (N): the total predicted resistance including the user-defined design margin at the corresponding speed.

Fv: the volumetric Froude number for the corresponding speed defined as $F_{nv} = \text{Speed} / (g * \text{DisplacedVolume}^{1/3})^{1/2}$

PPtotal (W): the calculated total propulsive power of the vessel dependent on the user-defined propulsive efficiency. For example:

Propulsive Efficiency Input	Propulsive Power Output
Quasi-propulsive efficiency	Delivered Power
Overall efficiency including gearing losses	Brake Power

PPtotal is defined as the total effective power divided by the propulsive efficiency and will be representative of the power defined by the propulsive efficiency input.

Prediction Check: at each speed the predicted condition of the vessel is checked against known valid ranges for the modified Holtrop method. The output is either OK, or specifies "Check=" followed by the number 1 through 3. The report provides the definition of each type of warning under the Prediction Checks section. We caution against using results where a prediction warning is found.

Results Plots

The last page of the report provides plots of bare and total hull resistance versus speed, total effective power and total propulsive power versus speed, and the residuary resistance and frictional resistance coefficients versus speed.

12.4 Export to NavCad

Menu	Orca3D > Speed/Power > NavCad Eport
Command	OrcaNavCadAnalysis

This command was created to interface Orca3D with the speed/power prediction program, NavCad, developed by HydroComp, Inc. (www.hydrocompinc.com).

The command exports the Rhino geometry model together with information describing the static equilibrium condition, hull type (monohull or catamaran), and speeds to analyze to a set of files that can be imported into NavCad for further analysis. The command requires that the geometry model form a closed solid (polysurface or mesh), and the assumption is made that the geometry represents

the bare hull excluding appendages. Effects of appendages can be accounted for explicitly in NavCad.

The static equilibrium condition can be determined in Orca3D either by specifying a weight and center of gravity or by specifying the flotation plane directly through values of sinkage, trim, and heel. As is the case throughout Orca3D, sinkage in this context refers to the perpendicular depth of the Rhino origin below the equilibrium plane. Two export options exist: the first one assumes you have NavCad installed and will launch NavCad and automatically import the script; the second option just exports the script and geometry files which can be imported into NavCad later through the NavCad script import functionality.

It is important for the user to recognize that at this stage of development, the interface to NavCad is intended to facilitate direct transfer of geometry and hydrostatics information. It is expected that the user will review and complete any required information for a full NavCad analysis including but not limited to things like appendage definitions, margins, and propulsor and engine information. For catamarans in particular, the information transferred is assumed to be for a single demi-hull, so the user may need to explicitly set values like the distance between demi-hulls.

Orca3D NavCad Interface

Mass Properties

☒ Weight/Center ☐ Float Plane

Displacement lbf Model Sinkage ft

LCG ft Model Trim deg

TCG ft Model Heel deg

VCG ft

Float Floated ship properties and estimated inertias may not match current in...

Floated Ship Properties

LOA ft

BOA ft

Depth ft

LWL ft

BWL ft

Tx ft

NavCad Export

Project Name

Project Path ...

Analysis Type

Hull Type

Speeds kt

Design Speed kt

Run NavCad ☐ Create Run Files Only **Close**

Part



13 Orca3D Marine CFD

Orca3D Marine CFD is a combination of Orca3D and the Simerics MP CFD software. When supplied as part of Orca3D Marine CFD, the Simerics MP package includes a specialized marine template for preparing the CFD simulation and carrying out typical analyses for marine vehicles (e.g., resistance, self-propelled performance, and water and air streamlines, etc.).

The Orca3D Marine CFD functionality is available with a Level 2 license. The Simerics MP CFD software, a separate standalone application, must be purchased separately in addition to Orca3D.

Orca3D is used to orient the hull to its static equilibrium flotation plane, create mesh representations of the geometry and generate stereo lithography (.stl) files for the meshes, define mass properties, inertia properties, optionally generate the propulsor representations used in self-propelled analyses, and define the parameters for the particular type of analysis being conducted (e.g., resistance analysis for a planing hull).

Once Orca3D has generated the Simerics input files, Simerics MP is started and the analysis files which Orca3D created are read. The CFD mesh is automatically generated from the .stl files, and the simulation is started by the user. Simerics MP is not a Rhino plug-in; it runs as a standalone software package. This allows you to continue to work in Rhino/Orca3D while the analysis is running in Simerics MP.

13.1 Overview and Resources

There are two basic steps to completing a CFD analysis using Orca3D Marine CFD:

1. Prepare the model and set up the analysis in the Orca3D Marine CFD dialog
2. Run the analysis in Simerics MP

Step 1 consists of making sure that your model is a closed polysurface or closed mesh (no naked edges), defining the static flotation condition, estimating inertias, defining the type of analysis, entering propeller information if doing a powered run, and the speed(s) or RPM(s) to be run.

Step 2 consists of starting the Simerics MP CFD software, and loading the run file (.spro) that Orca3D created. Simerics MP will automatically generate the CFD mesh, and the user simply clicks the “Start” button to begin the simulation. Before starting the simulation, the user can also vary parameters such as the simulation time, number of time steps, and acceleration profile. During the simulation, you can monitor values such as heave, pitch, pressure and shear force, resistance, velocity, acceleration, etc.

Helpful Resources

- In addition to the information in this Help file, there are numerous

FAQ articles in the [Orca3D Knowledge Base](#).

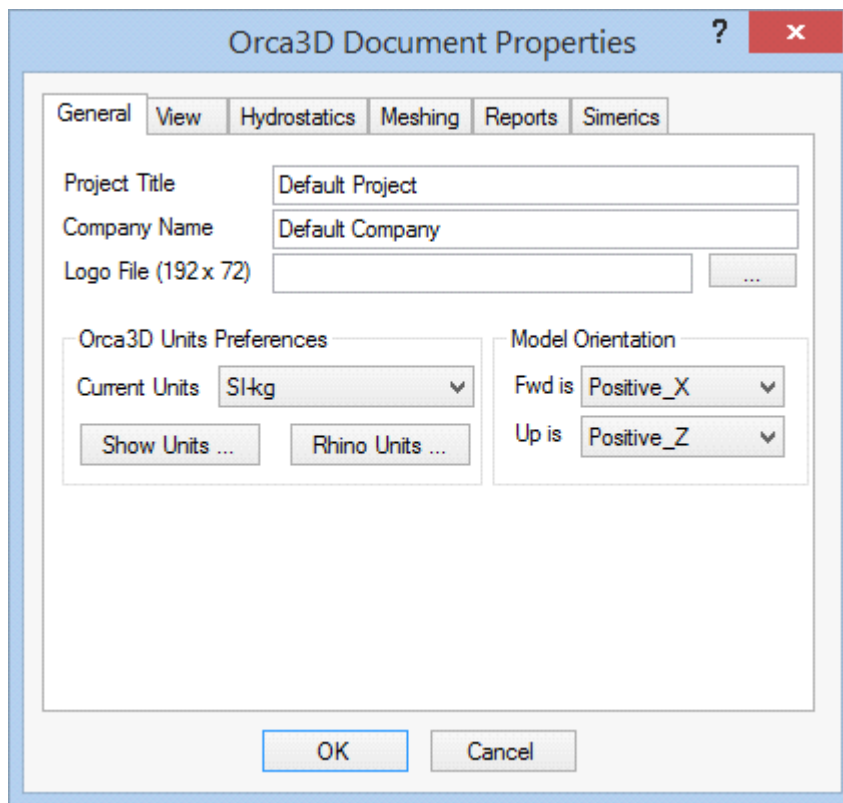
- The Simerics-MP Help file is also a useful resource, although it is more general and less marine-specific than this Orca3D Help file. In particular, it is worth reading the section on *Numerics and Convergence*. It's not necessary to read and understand the theory, but the overview is helpful to understand how the program is discretizing time and space and solving the equations iteratively.
- Send any questions to support@orca3d.com

13.2 Setting up the Simulation in Orca3D

This section will guide through the process in Orca3D of setting up the simulation that will be run in SimericsMP.

13.2.1 Setting Orca3D Properties

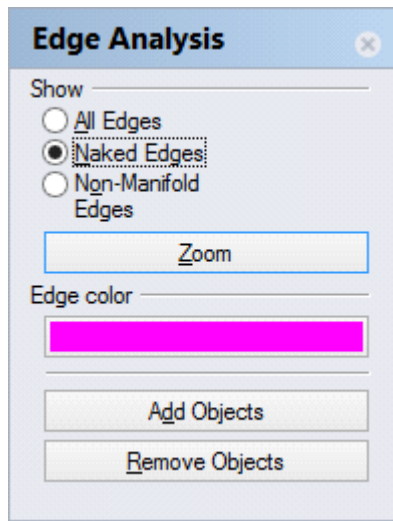
Orca3D Properties: As with any analysis in Orca3D, it's important to have the Orca3D Properties properly set. These include the units (other than the length unit, which is set in Rhino's Properties), the Forward and Up directions, and the Water Density. Select the Orca3D Properties command in the Orca3D menu resulting in the dialog shown below:



[Set the units](#)⁷⁷ to the desired system, and be sure that your Model Orientation is correct (Fwd and Up). Next, go to the Hydrostatics tab and set your Fluid Type, and if desired, enter a Mass Density (there are defaults for Seawater and Freshwater). Finally, go to the Simerics tab to enter the path to the Simerics.exe executable on your hard drive.

13.2.2 Model Requirements for CFD

Model Requirements: To run a CFD analysis, your model must be made up of one or more closed polysurfaces or closed meshes which represent the entire hull (port and starboard). Appendages may be included as part of the hull (if they are properly trimmed to the hull and are part of the closed polysurface/mesh), or they may be a separate closed polysurface or closed mesh. This means that there cannot be any naked edges. To determine if there are any naked edges, use the Rhino command “showedges.” The Edge Analysis control will be displayed as shown below. Be sure that “Naked Edges” are selected and a high contrast color is chosen as the Edge color.



Typically naked edges result from surfaces or meshes which are not joined exactly. You may have to un-trim and re-trim the surfaces, perhaps with a looser tolerance.

There is a good resource on the McNeel website to help with the process of making sure that your model is closed. Note as the last part of the discussion they talk about creating a closed mesh instead; Orca3D Marine CFD does also work with closed meshes, and sometimes the mesh repair tools (e.g., AlignMeshVertices) can be an easier path than closing a surface model.

<https://wiki.mcneel.com/rhino/faqclosedsolids>

Unless you are interested in air streamlines around the superstructure, it's usually easier to put a simple deck surface on the model. This will also simplify the mesh and reduce the analysis time, and unless it's a high-speed craft it will not have much effect on the results. You should also consider the need for general "de-featuring" of your Rhino model for CFD analysis. Rhino models are created for many purposes of course, not just for analysis. For example, a model may include features/details which are intended to generate photorealistic renderings used in advertisements. Details such as hardware, engines, hatches, coamings, and other equipment that may have been built into the model should generally not be included in the CFD model. There are instances where you may be interested in the detailed flow around some detailed geometry, in which case the mesh will need to be resolved and CPU effort will increase. The "cleaner" your Rhino model, the easier it will be to create a well-conditioned CFD mesh. Models that consist of many small surface patches, fit together within a tolerance, will be more difficult to mesh than models with just a few, large surfaces which match topologically. This is not unique to CFD, of course. The same tenet applies for the goals of achieving a model which is fair, and which can be used for numerically controlled milling machines, 3D printing, or high-end rendering.

13.2.3 The Marine CFD Interface

The Orca3D Marine CFD Interface: The next step is to set up your CFD analysis.

Select your closed polysurface(s)/mesh(es), sometimes called a "watertight solid." The model must

include the entire vessel (port and starboard halves). In the Orca3D menu, select Speed/Power -> Marine CFD. If your model is not closed, you will get an error message that it is not a watertight solid. Otherwise, the Orca3d Marine CFD dialog will open. The parameters in the dialog are described below. At the end of this process, Orca3D will create the following files:

- Mesh geometry files (stereo lithography .stl files) for the hull, deck, and transom surfaces
- Simerics .spro files(s), which contains all of the setup information for the analysis
- Simerics .sdsp file(s), which contains information on the default viewing parameters.

Simerics MP uses these files to automatically generate the CFD mesh and set up the CFD analysis.

Orca3D Marine CFD

Mass Properties


☐ Weight/Center ☒ Float Plane

Displacement: 44.869 tonne-f Model Sinkage: 1.500 m

LCG: -15.833 m Model Trim: 0.000 deg

TCG: 0.000 m Model Heel: 0.000 deg

VCG: 0.000 m

 **Float** Floated ship properties and estimated inertias may not match current input values.

Floated Ship Properties

LOA: 31.384 m

BOA: 2.415 m

Depth: 3.071 m

LWL: 29.981 m

BWL: 2.370 m

Tx: 1.500 m

Inertias

☒ Kroll/BOA: 0.296

☒ Kpitch/LOA: 0.261

☒ Kyaw/LOA: 0.300

Iroll: 22924.919 kg-m²

Ipitch: 3010623.542 kg-m²

Iyaw: 3977571.069 kg-m²

Simetrics Analysis

Project Name: Delft Catamaran

Project Path: C:\Users\Documents\Data\Delft Catamaran\

Analysis Type: Resistance

Hull Type: HighSpeedDisplacement

Simulation Speeds: 10,15,20,25 kt

Attribute Faces

☐ Full Asymmetric Run

Run Simulation ☐ Create Run Files Only **Options ...** **Close**

13.2.3.1 Mass Properties/Flotation

Mass Properties: The next step is to define the flotation condition that will be used in the CFD analysis. This is very similar to other hydrostatics calculations in Orca3D. You can define the flotation condition with a Float Plane (Sinkage, Trim, and Heel), or a Weight and Center of Gravity. In either case you must also enter a VCG. See [Defining the Flotation Condition](#)²⁶¹ for more details. After entering the values, click on the yellow “Float” button. Once the hull is in equilibrium, the Float button will turn green. If you make any changes to the mass properties, the button will turn back to yellow, indicating that you should click Float again so that the hull is in equilibrium (before clicking the Run Simulation button, all of the yellow buttons should be green). The Floated Ship Properties will be shown, and the sinkage, heel, and trim will be displayed if the weight/CG were entered or

displacement and CG will be displayed if a float plane was entered. These results can be used as a check to be sure that the flotation condition is correct.

Inertias: In order to predict the performance of the vessel, Simerics MP must have estimates of the roll, pitch, and yaw inertias. If you don't know these values, they can be estimated as a function of gyradius for each axis, non-dimensionalized by beam for the roll gyradius and the length for the pitch and yaw gyradii. The default values for these non-dimensional parameters are 0.40, 0.25, and 0.25, respectively. Note that if the Displacement, Length, or Beam is changed by changing the static equilibrium condition, the inertias computed from estimated gyradii will also change.

To compute the inertias based on these values, leave the boxes checked. If you want to enter the inertia directly, uncheck the box.

13.2.3.2 Basic Settings

Simerics Analysis Setup: The lower part of the Orca3D Marine CFD dialog is where you define the details of the analyses to be run. Each input is described below.

Project Name: This will default to the Rhino .3dm file name, and it will be used as the root for the files that are created (.spro, .sdsp). The Project Name will have the speed (for Resistance runs) or simulation number (Powering runs) appended to it. For example, if the Project Name is "MyBoat" and you are computing Resistance at 15 knots, the files will be "MyBoat_15kt.spro" and "MyBoat_15kt.sdsp".

Project Path: The path to the folder where the files will be created. Subfolders will automatically be created for each simulation associated with a speed or propulsor rpm setting.

13.2.3.3 Analysis Type

Analysis Type: The two types of analyses that are available are Resistance and Powering.

Resistance is equivalent to an EHP test in a towing tank. The vessel is "towed" at the center of gravity, and is accelerated until it reaches the desired speed. The simulation continues until you reach the specified simulation time or you feel that the solution has converged (see the Convergence section for more information on this).

A Powering analysis propels the vessel with thrust along the shaft line(s), at a user-defined RPM. The propulsor is modeled as a Hough-Ordway* actuator disk, which not only generates the required thrust, but also imparts axial and tangential velocities to the flow field around the propulsor. The vessel will naturally accelerate until it reaches an equilibrium speed (see the Convergence section for more information on this). Note that propeller cavitation is not modeled in the simulation. This option requires the definition of one or more propellers and their performance parameters. If Powering is selected, a second tab, Propulsors, will be shown.

*Hough, G. R., and D. E. Ordway. The Generalized Actuator Disk. Technical Report, Ithaca, New York: Therm Advanced Research, Inc., 1964.

The screenshot shows the 'Simerics Analysis' window with the 'Propulsors' tab selected. On the left, there is a list of propulsors (currently empty) with icons for adding (+), deleting (X), and copying. In the center, there is a graph showing a propeller's performance curves. On the right, there are input fields for the following properties:

- ID: [Empty]
- Type: [Dropdown menu]
- Rotation: [Dropdown menu]
- Performance ...: [Button]
- Diameter: [Empty] m
- Hub Diameter: [Empty] m
- Thickness: [Empty] m
- Location: [Empty] m
- Angle To BL: [Empty] deg
- Angle To CL: [Empty] deg
- Place ...: [Button]

To begin, click the + icon to add a new propulsor, and then enter the information for that propulsor.

The screenshot shows the 'Simerics Analysis' window with the 'Propulsors' tab selected. The list of propulsors on the left now contains 'Propulsor: 1'. The input fields on the right are populated with default values, and the 'Performance ...' button is highlighted in yellow. The following table summarizes the data shown in the screenshot:

Property	Value	Unit	Status
ID	Propulsor: 1		Default
Type	Propeller		Default
Rotation	[Dropdown]		Warning (Red !)
Diameter	0.000		Warning (Red !)
Hub Diameter	0.000	m	
Thickness	0.000		Warning (Red !)
Location	0.000,0.000,0.00	m	
Angle To BL	0.000	deg	
Angle To CL	0.000	deg	

The Propulsor information includes:

- **ID:** This is set automatically when you add a new propulsor.
- **Type:** Currently the only type is Propeller.
- **Rotation:** Left-hand or Right-hand. Right-hand turns clockwise when viewed from behind the propeller. If you are doing a symmetric run (e.g., the boat has an even number of outboards and you do not check the "Solve Full Asymmetric Problem..." checkbox), then you are defining the propeller(s) on the port side of the vessel. Be sure to set the Rotation accordingly.
- **Diameter:** Overall diameter of the propeller.
- **Hub Diameter:** Diameter of the hub of the propeller.
- **Thickness:** Longitudinal dimension of the propeller; distance from front to back when viewed from the side.

- **Location:** X, Y, Z coordinates of the center of the forward face of the hub.
- **Angle to BL:** Shaft angle to the baseline, when viewed from the side, measured down from the horizontal. A horizontal shaft line has an Angle to BL of 0. A shaft line that goes down as it goes aft has a positive Angle.
- **Angle to CL:** Shaft angle to the centerline, when viewed from below. A shaft line that is parallel to centerline has an Angle to CL of 0. A shaft line that is angled outboard as it goes aft has a positive Angle.
- **Place:** The Place button allows you to set the Location, Angle to BL, and Angle to CL interactively.
- **Performance:** Click the Performance button to bring up the Propulsor Performance dialog.

The screenshot shows the 'Simerics Propulsor Performance' dialog box. It is divided into two panes. The left pane, titled 'Propulsor Performance Characteristics', contains three radio buttons: 'B-Series' (selected), 'Custom Kt/Kq', and 'Constant Thrust/Torque'. Below these are three text input fields labeled 'Number of Blades', 'Expanded Area Ratio', and 'Pitch/Diameter Ratio'. The right pane, titled 'Propulsor Force Time Profile', contains two radio buttons: 'Fixed RPM' (selected) and 'Linear RPM Ramp'. Below this is a 'Target RPM' text input field. At the bottom of the dialog are 'OK' and 'Cancel' buttons.

There are three options for defining the Propulsor Performance Characteristics. In each case, files defining the Kt and Kq curves will be created which Simerics will read. These files will be kt?.txt and kq?.txt, where ? is the numerical ID of the propulsor (e.g., for Propulsor 1 they will be kt1.txt and kq1.txt).

This is a close-up of the 'Propulsor Performance Characteristics' section. It shows the 'B-Series' radio button is selected. Below it are three empty text input fields for 'Number of Blades', 'Expanded Area Ratio', and 'Pitch/Diameter Ratio'.

- **B-Series:** You may define your propulsor as a B-Series propeller. Enter the Number of Blades, Expanded Area Ratio, and the Pitch/Diameter Ratio. The kt and kq files will be generated using B-Series data.

Propulsor Performance Characteristics

☐ B-Series
☒ Custom Kt/Kq
☐ Constant Thrust/Torque

	J	Kt	Kq
*			

< >

- Custom Kt/Kq: Enter a table of J, Kt, and Kq values. These will be written to the kt and kq files.

Propulsor Performance Characteristics

☐ B-Series
☐ Custom Kt/Kq
☒ Constant Thrust/Torque

Thrust N
 Torque kgf-m

- Constant Thrust/Torque: Enter a constant Thrust and Torque to be used.

Next, enter the propulsor force time profile. If you select "Linear RPM Ramp," enter the number of seconds of simulation time for the RPM to reach the full value. It will increase from zero to the Target RPM linearly over the Ramp Time.

Propulsor Force Time Profile

☒ Fixed RPM
☐ Linear RPM Ramp

Target RPM

or

Propulsor Force Time Profile

☐ Fixed RPM
☒ Linear RPM Ramp

Target RPM

Ramp Time

Wake Fraction

Hull/Propeller Interaction

☒ Specify Wake Fraction

	Speed (kt)	1 - wt
	15	0.9
	20	0.95
...	25	0.98

An additional option for a self-propelled analysis is the ability to specify the speed-dependent wake fraction values for each propulsor. As noted above, the propulsor thrust and torque characteristics are defined by the propeller open water characteristics, either entered directly or approximately through specification of an equivalent standard series propeller. In either case, the open water thrust and torque curves are a function of the propeller advance coefficient, J , where

$$J = V_a / (nD)$$

where n = propeller rotation rate in revolutions per second, D is the propeller diameter, and V_a is the inflow speed of advance at the propeller. By default the Orca3D Marine CFD self-propelled simulation assumes V_a = the component of V_s (the speed of the ship) along the direction of thrust. In Orca3D Marine CFD, the user is given the option of specifying a wake fraction, $1 - wt$ (known as the Taylor wake fraction), that will be applied to the component of ship speed along the direction of thrust. Values of $1 - wt$ are often between 0.9 and 1.0, although they can sometimes vary outside of that range. Although these values are often derived from self-propelled model tests (using measured thrust and/or torque values from the model propellers) they are sometimes approximated from resistance model tests using the mean or nominal wake fraction in way of the propeller disk. Orca3D Marine CFD allows the user to input a table of speed-dependent wake fraction values, which may have come from scale model tests, empirical estimation methods, rules of thumb, or even CFD simulations. The speed reference here is the ship speed, and the input wake fraction is $1 - wt$ (not just w whose values are much smaller). If the user wishes to specify wake fractions to apply to the self-propelled simulation, they should check the box to "Specify Wake Fraction" and then enter the speed-dependent values. If the ship speed is outside of the specified values, a value will be obtained by extrapolation. If only a single ship speed and wake fraction is entered, this value will be assumed constant for all speeds.

13.2.3.4 Hull Type and Speeds

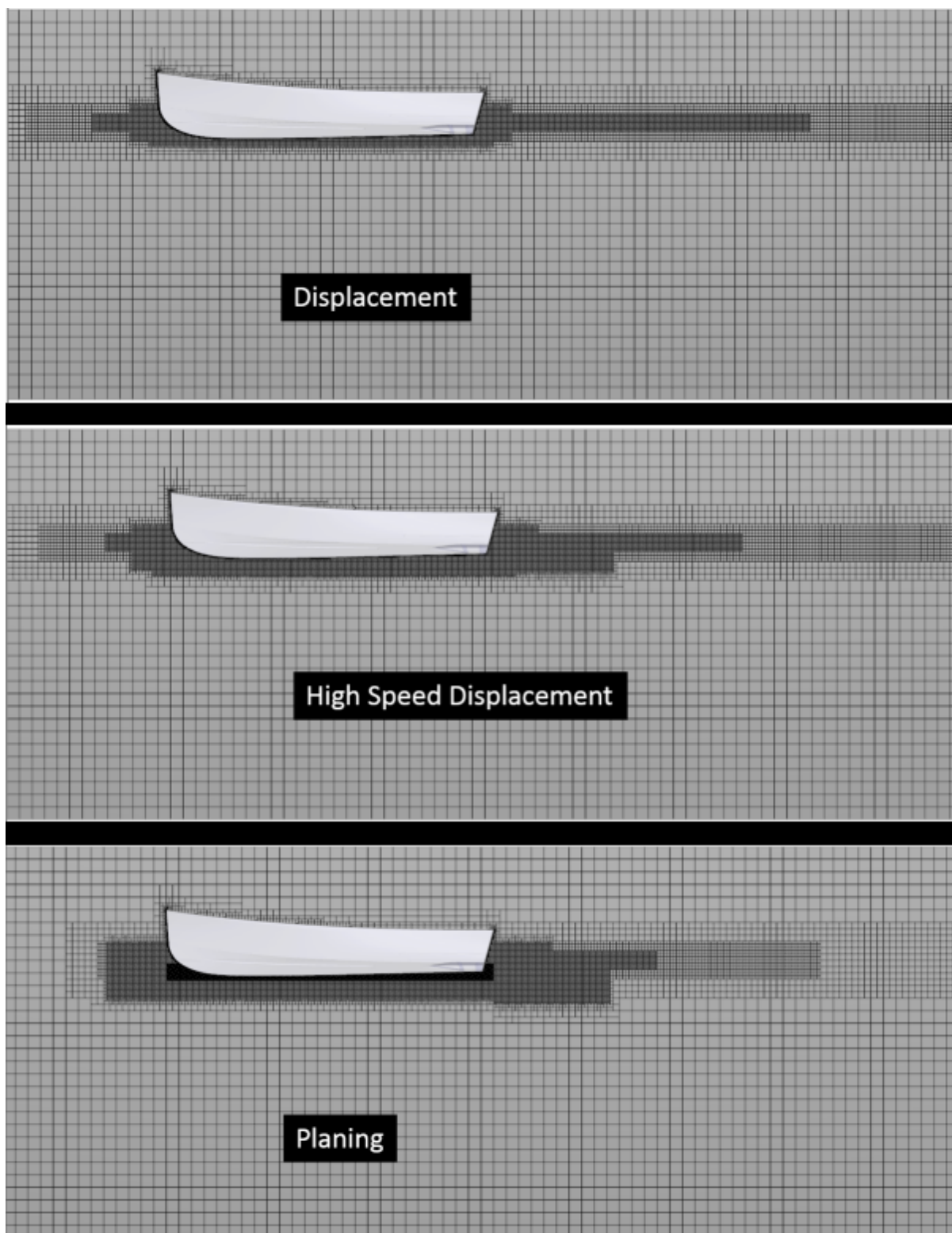
Hull Type: Choose between the Planing, High Speed Displacement, Displacement, Low Speed, or Submerged Body template. This will affect the size and shape of the CFD mesh around the hull. Planing hulls will, in general, heave and pitch more than displacement hulls, so there will be a larger region of the CFD mesh which is of higher density. The Planing template use an Explicit Volume of Fluid (VOF) solver, whereas the High Speed Displacement, Low Speed, and Displacement templates

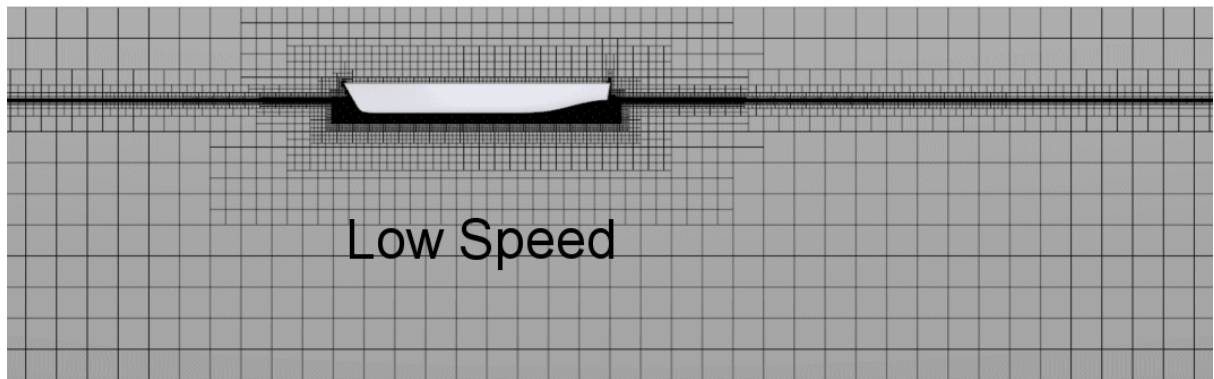
uses an implicit solver. The VOF explicit solver can better capture the sharp interface of the free surface, especially with spray and other violent flows. There may be a penalty in time-step and/or iteration count. The extra refinement around the hull will improve the resolution of the wake in high speed displacement hulls, and reduce the entrained air at the hull boundary in planing hulls. For displacement hulls, use the High Speed Displacement Hull template when the Froude number is over 0.5.

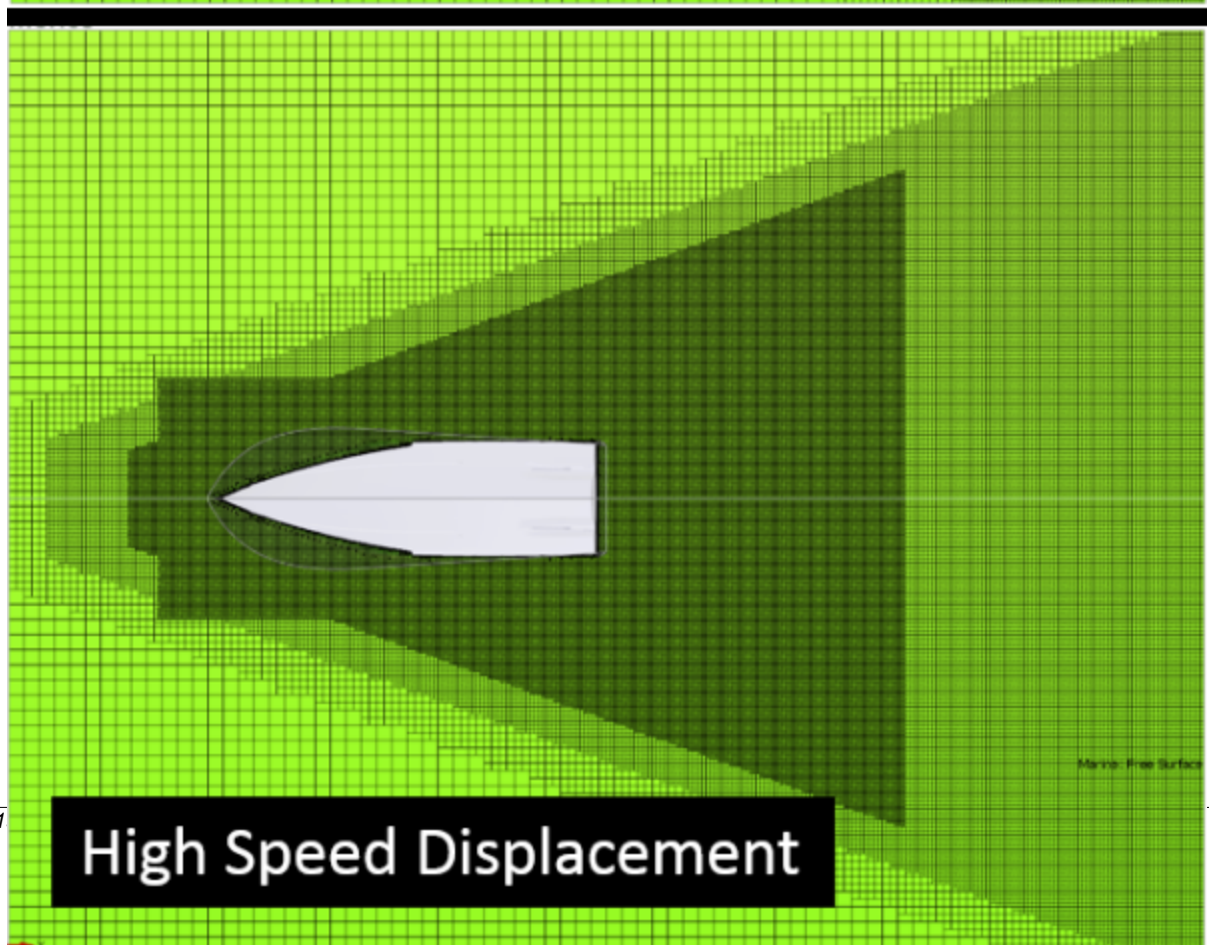
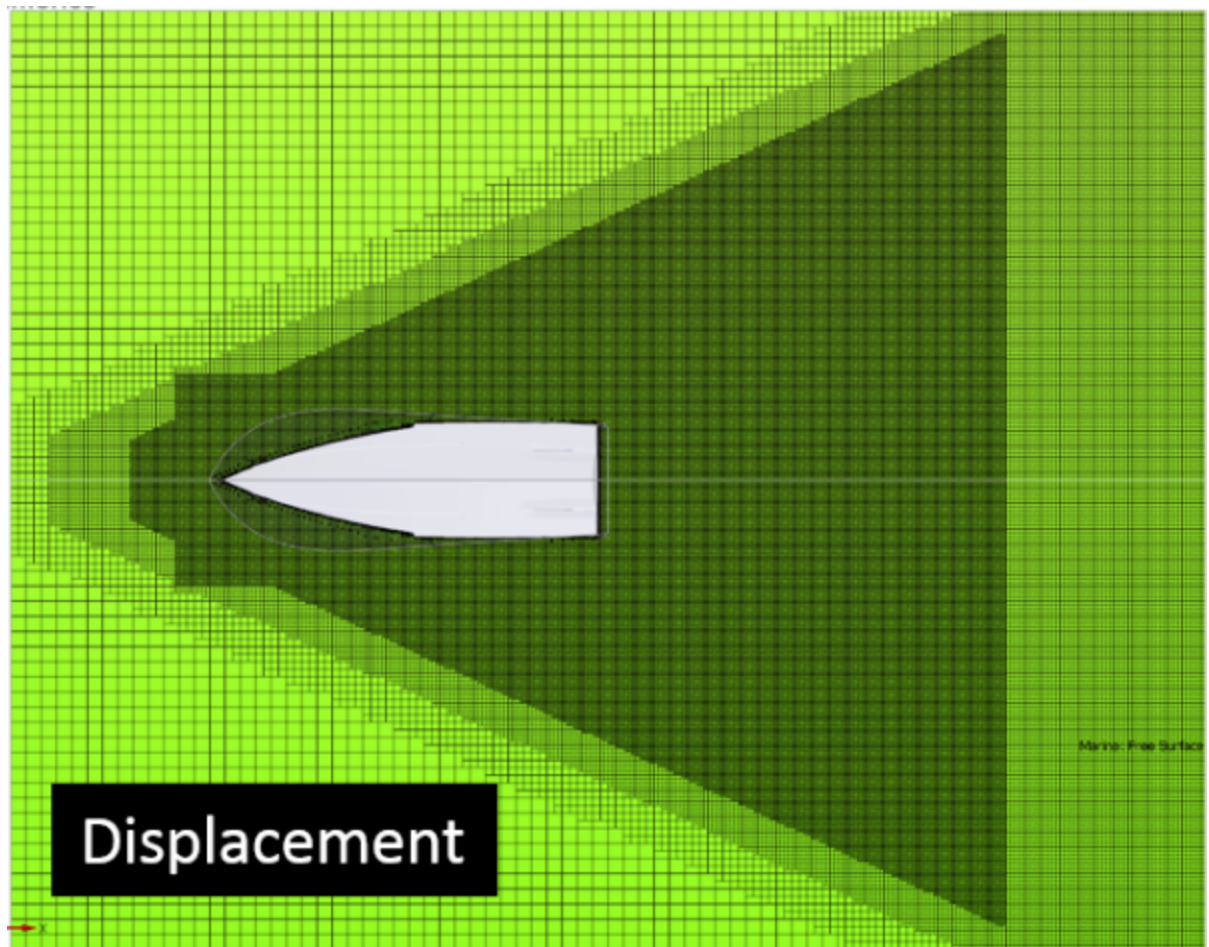
The Low Speed hull type may be appropriate for full, low L/B hull forms running at lower Froude numbers where the ship-generated waves are relatively small (and therefore the wave-making resistance is a relatively small part of the total resistance). The marine template makes adjustments to the simulation for these conditions to improve resolution of the free surface waves. One possible issue with low speed analyses is that you may find reflections from the boundaries of the domain. This can show up graphically and also as high frequency oscillations in the heave, pitch, and resistance time histories. In this case, you will need to both enlarge the domain size and apply damping to the boundaries. Be aware that this will increase the number of cells in your grid and therefore increase the time to run the simulation. Contact support@orca3d.com if you need assistance with this template.

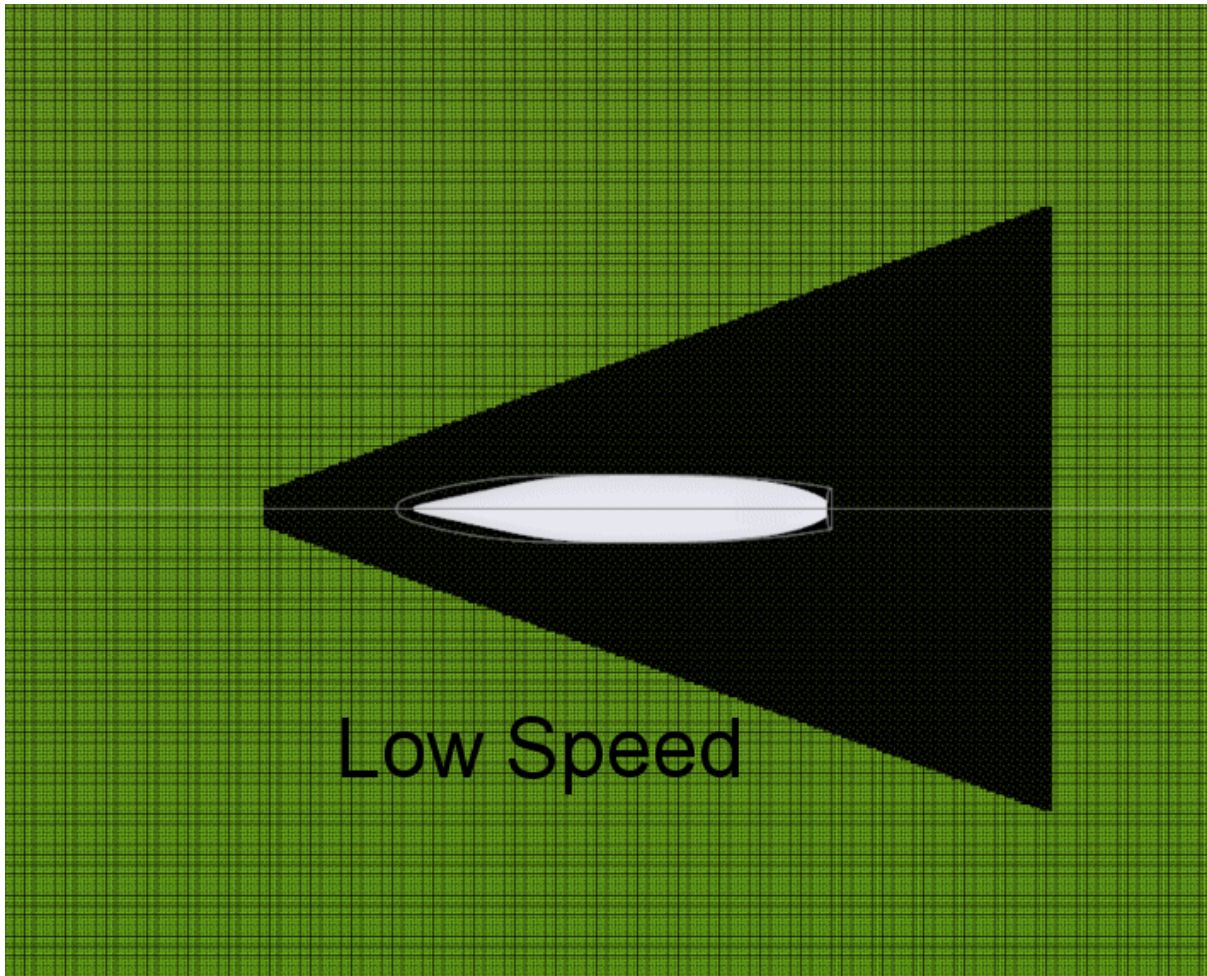
The Submerged Body template requires the Premium version of Orca3D Marine CFD. In this case, there is no free surface in analysis. As submerged bodies are frequently bodies of revolution, it is suggested that you adjust the [default surface mesh parameters](#)^[389] to be sure that the Rhino model is not coarsely faceted before export to SimericsMP for meshing. You should create [refinement zones](#)^[389] around the model and any appendages. The first refinement zone can be just slightly larger than the hull boundaries (perhaps 10%). The second zone should be larger (perhaps twice the size of the hull) and slightly coarser. This creates a gradual increase in cell size from the hull boundary to the free stream. These are guidelines to begin your mesh sensitivity study, to determine the best tradeoff between accuracy and run-time.

The figures below show the different shapes and sizes of the CFD mesh for using the templates.







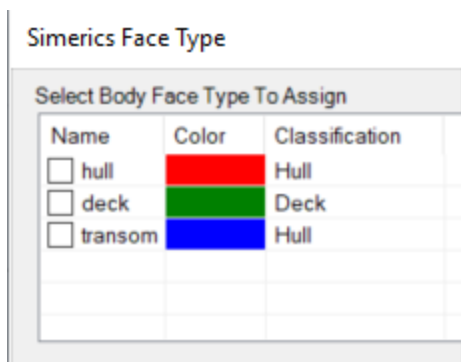


Simulation Speeds (or Nominal Speeds): For Resistance analyses enter the speeds which you want to simulate (note: the unit for speed is set in [Orca3D Properties](#)^[77]). The Simerics project (.spro) and display (.sdsp) files are created for each speed to be run. The speed is also used to set parameters for simulation time and the number of time steps. For Resistance analyses, the vessel will be towed at the Simulation Speed(s). For Powering analyses, enter the Nominal speed which you expect the vessel to achieve for each RPM that you have entered in the Propulsor tab. It is not critical that the Nominal speed be exact; it is simply an estimate that is used to set the parameters for the simulation time and number of time steps. The actual speed attained will depend on the thrust from the propeller.

Note: each speed or RPM that you have entered is a separate analysis in Simerics, which must be started separately (or see the Options section to learn about automating multiple analyses with a Python script).

13.2.3.5 Attributing Faces

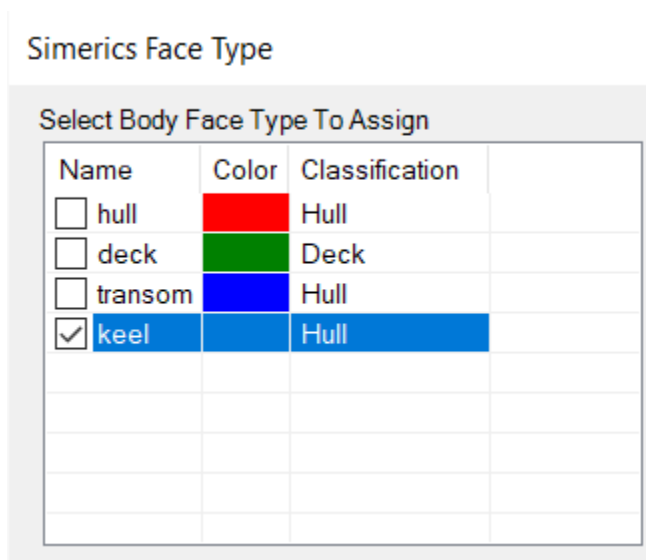
Attributing Faces: When you click on the Attribute Faces button, you will see this control:



Name Categories

All of the surfaces/meshes making up the closed model must be assigned to one of the Name categories. The default Name categories are Hull, Deck, Transom, and Appendages (for previously saved models, you may need to add the Appendages Name category). As a minimum, the model must have surfaces/meshes in the Hull and Deck Name categories. The Name categories will allow you to control the display of the various parts of the model in Simerics, and also to see results for the various parts of the model. Once your analysis is complete, you can see results for the entire model, or by individual Name categories.

You may create new Name categories. For example, you may wish to create a new Name category for keel, and assign the keel surfaces/meshes to that Name category. To add a new Name category, right click on the grid and select Add. Then enter the name of the new category. By default, it will have a Classification of Hull. This is appropriate for any surfaces that may be wet during the simulation. If you want to change the Classification, left-click on the Classification.



Each Name category has a color and a Classification. You can change the color by clicking on the color.

Classification

The Classification has three options: Hull, Deck, and Appendage. These Classifications are used by the meshing template. Surfaces with the Hull and Appendage Classifications are gridded more finely than the those with Deck.

If your model has appendages which protrude below the baseline of the hull, you may want to assign them to the Appendage Name category or create a new Name category (e.g., keel) and classify it as an Appendage. The “Appendage” face classification can be used to exclude one or more model faces from the “hull” bounding box calculation during CFD grid refinement. Faces classified as Appendages still have their own grid refinement zone around them, but in the case where an appendage extends well outside of the bounding box of the rest of the hull (such as a fin keel on a sailboat or a foil on a hydrofoil) this avoids unnecessary grid refinement caused by an artificially large hull bounding box. Again, to change the Classification for a Name category, left-click on the Classification and select from the drop down list, as shown below.

Simerics Face Type

Select Body Face Type To Assign

Name	Color	Classification
<input type="checkbox"/> hull		Hull
<input type="checkbox"/> deck		Deck
<input type="checkbox"/> transom		Hull
<input checked="" type="checkbox"/> keel		Hull

Hull
 Deck
Appendage

Assigning Faces

To begin, all of the surfaces in your model are assigned to be of type Hull, and so are red. Select Deck in the Name column, and then click on each surface that comprises the deck and superstructure. Then do the same for the Transom and Appendages if you wish to have surfaces in those Name categories (remember, only Hull and Deck are required). If you accidentally click on the wrong

surface, simply go back to the correct Name category for that surface, and then select the surface.

When the process is complete, right-click or hit Enter to return to the main dialog. Remember, you must select at least one deck and one hull surface/mesh in your model to run the CFD analysis.

13.2.3.6 Symmetric or Asymmetric Run

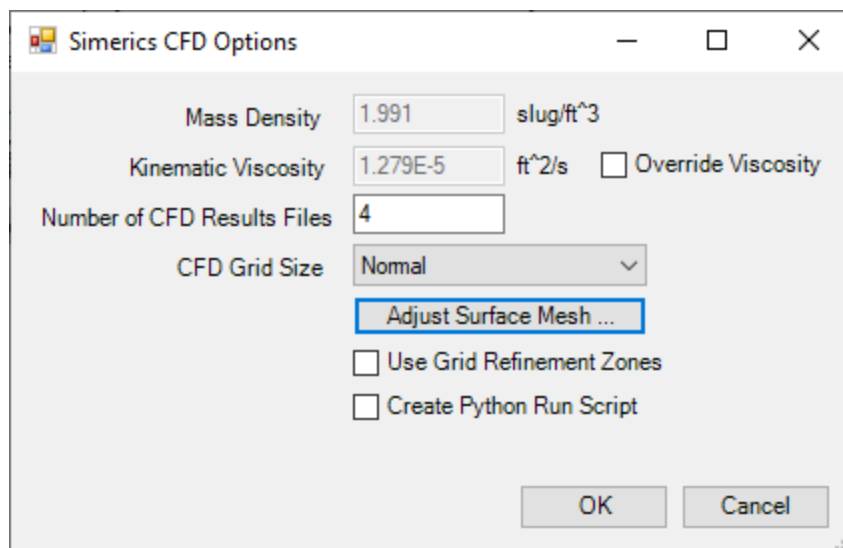
Full Asymmetric Run: If you are doing an upright, zero yaw Resistance analysis and your model has port/starboard symmetry, leave this box unchecked. This allows the CFD analysis to be run with the assumption of symmetry across the centerplane, which reduces the run-time by half. The same is true for Powering analyses with an even number of propellers. If you have an odd number of propellers, you should check this box since one propeller will be on centerline (if you do not check the box, the thrust of the centerline propeller will be mirrored and therefore doubled). [There is a method of running a Symmetric analysis with a centerline propeller](#)⁴²⁴, which will save simulation time (but ignore the rotational flow induced by the propeller).

If you are running a Resistance calculation with heel or yaw, you should check this box to solve the full asymmetric problem. Note that running a full asymmetric analysis will significantly increase the time required. If you are doing a symmetric powered run (e.g., there are two outboard engines), you should define the engine on the port side of the vessel (i.e., enter the Rotation for the engine on the port side).

Note that if you leave the box unchecked (i.e., you are doing a symmetric run), just half of the model is being analyzed. In Simerics you will see a mirrored image (in the Properties panel, click the View tab; scroll down to Global Parameters and click on the small arrow next to it to expand it. You will see the Mirror attribute, and it will be set to Y). ***It's important to note that many results, which are not marine-specific, will be for just half of the hull.*** For example, the Shear Force and Pressure Force will be for half of the vessel. Marine-specific values such as EHP and Total Resistance are for the entire vessel.

13.2.3.7 Options: Grid Refinement and more

Options: Click the Options button to adjust the Mass Density, Kinematic Viscosity, the number of results files to save by default, the CFD Grid Size, the Surface Mesh, or create a Python script to run multiple speeds or RPMs.



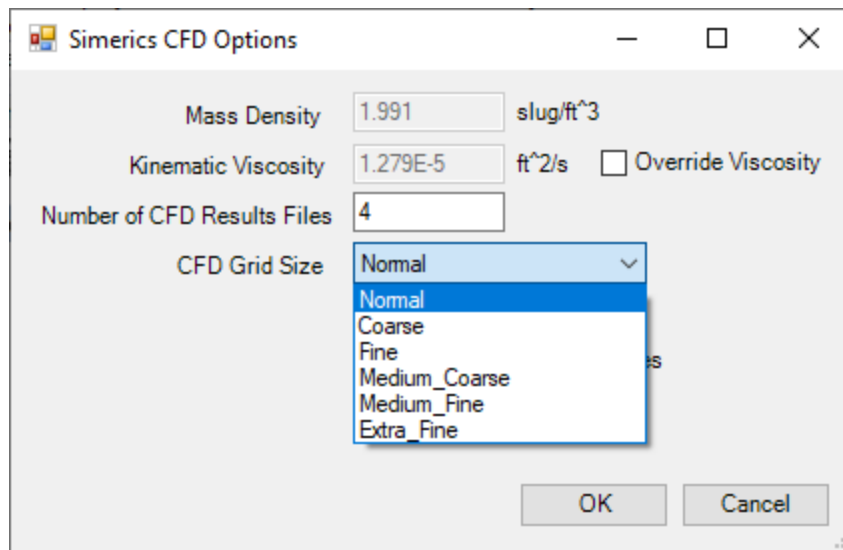
Mass Density: The Mass Density is set in [Orca3D Properties](#) ⁷⁷.

Kinematic Viscosity: The Kinematic Viscosity is set by default to correspond to the Mass Density. However, you can enter a different value.

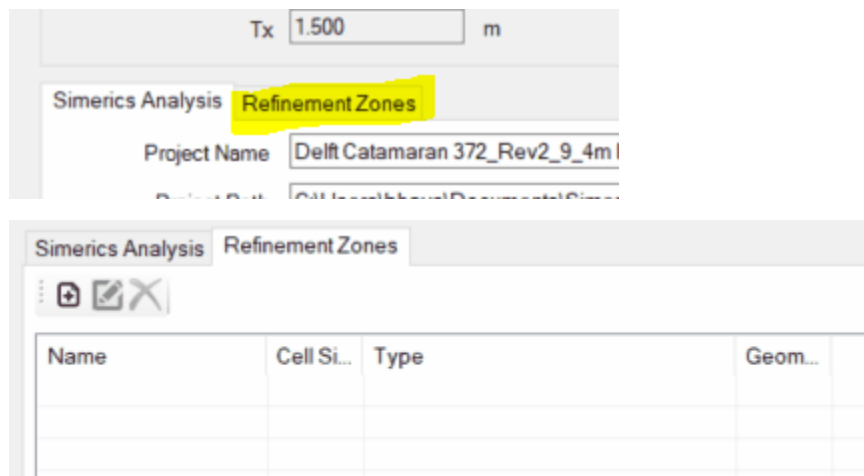
Number of CFD Results Files: This controls how many results files (.sres) are saved during the course of a simulation. These files have two uses; first, if the analysis stops for some unexpected reason (a crash, computer reboot after operating system update, etc.), you can restart the simulation from the last .sres file that was saved, rather than having to start over from the beginning. Second, when animations are created, each .sres file will be used to create one frame in the animation (typically an animation would have 10 or more frames, so if you plan to create animations you will want to increase this number from the default of 4). However, keep in mind that the .sres files can be very large (e.g., 750 MB).

CFD Grid Size: The mesher in Simerics uses a template based on the Hull Type (Planing, Displacement, High Speed Displacement) and the CFD Grid Size (Coarse, Medium Coarse, Normal, Medium Fine, Fine, Extra Fine). It is not recommended to use Coarse or Medium Coarse for actual simulations; they can be used in a learning context where you want the simulations to run very quickly but you will not be using the results.

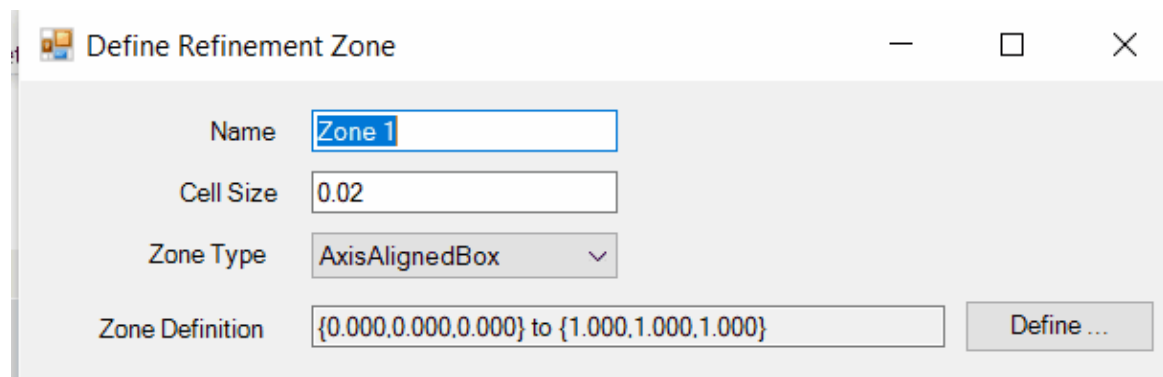
In general, the finer you make this setting, the more accurate your CFD answer should be, but the longer it will take to run. It's recommended that you conduct a grid refinement study, to determine the appropriate selection for your analyses (i.e., the "coarsest" setting that will still give you good results; that is, going up to a finer grid does not significantly change the results). Pick one speed, say the design speed, and do a study where you run Normal, Med Fine, Fine (and maybe Extra Fine) and see how the resistance or speed varies. Then you can decide which setting to use with the rest of the speeds.



Use Grid Refinement Zones: The overall grid refinement can be controlled with the CFD Grid Size, as well as by making adjustments in Simerics (see [Changing the Mesh in SimericsMP](#)⁴³³). But you can also create local refinement zones, which might be used around an appendage, intake, etc. This can be done in SimericsMP, but it requires the user to input the coordinates for the refinement zone numerically (and those coordinates are with the vessel transformed to the equilibrium flotation plane), whereas this option in Orca3D allows you to do it graphically. Grid Refinement Zones may be Axis Aligned Boxes or Cylinders. To create a Grid Refinement Zone, check the "Use Grid Refinement Zones" box and then click OK. A new tab will appear in the CFD dialog called "Refinement Zones."

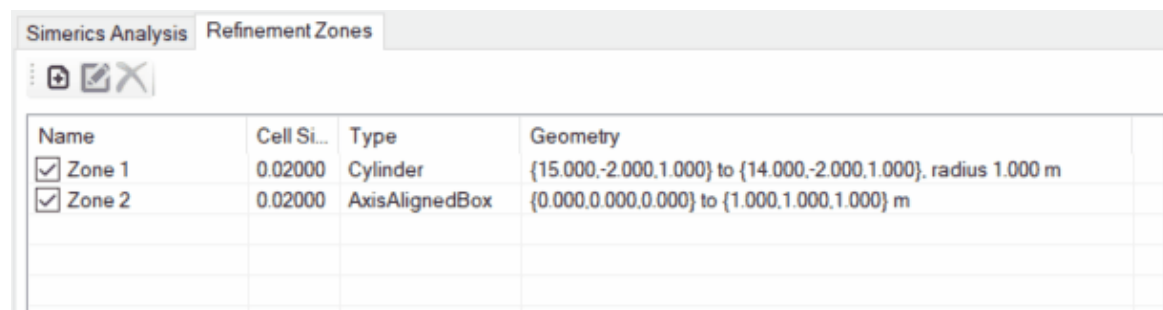


To add a new zone, click the + icon, or right-click and select Add. The Define Refinement Zone dialog will be shown:



The Cell Size is relative to the Size Reference, which by default is the Maximum Dimension (normally the length of the vessel). Choose a Zone Type, and enter the appropriate coordinates. This is the opposite corners for a Box, and for a cylinder the coordinates of the ends of the axis, followed by the radius; e.g., {15.000,-2.000,1.000} to {14.000,-2.000,1.000}, radius 1.000

By clicking the Define button, you may define the box or cylinder graphically in Rhino. To size and place them precisely, it may be easier to create points, boxes, or cylinders in Rhino before starting the CFD command, to give yourself geometry to snap to when creating the box or cylinder.



If you want to remove a Zone, select it in the list and then right-click and select Delete, or click the X icon. To edit it, select it and right-click and select Edit, or click the edit icon. If you don't want to delete the definition but you do not want it to be included in the file that is created for Simerics, uncheck the box.

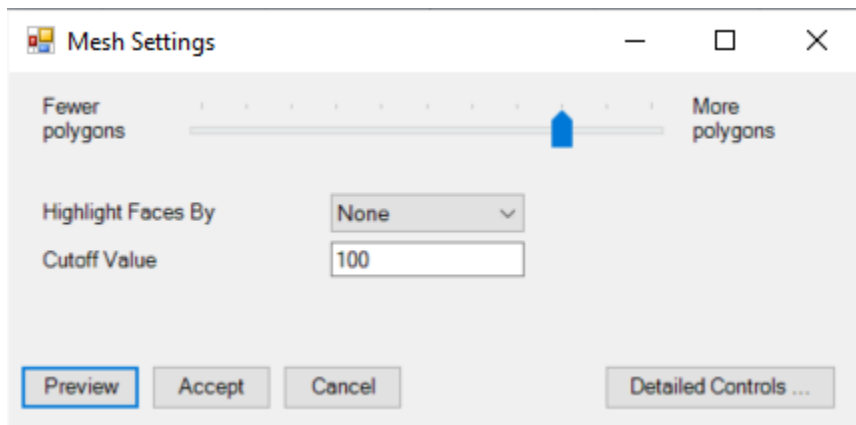
Create Python Run Script: Using the Python scripting language, multiple analyses can be automated so that after each analysis finishes, the next will begin. See [Running Multiple Speeds](#)

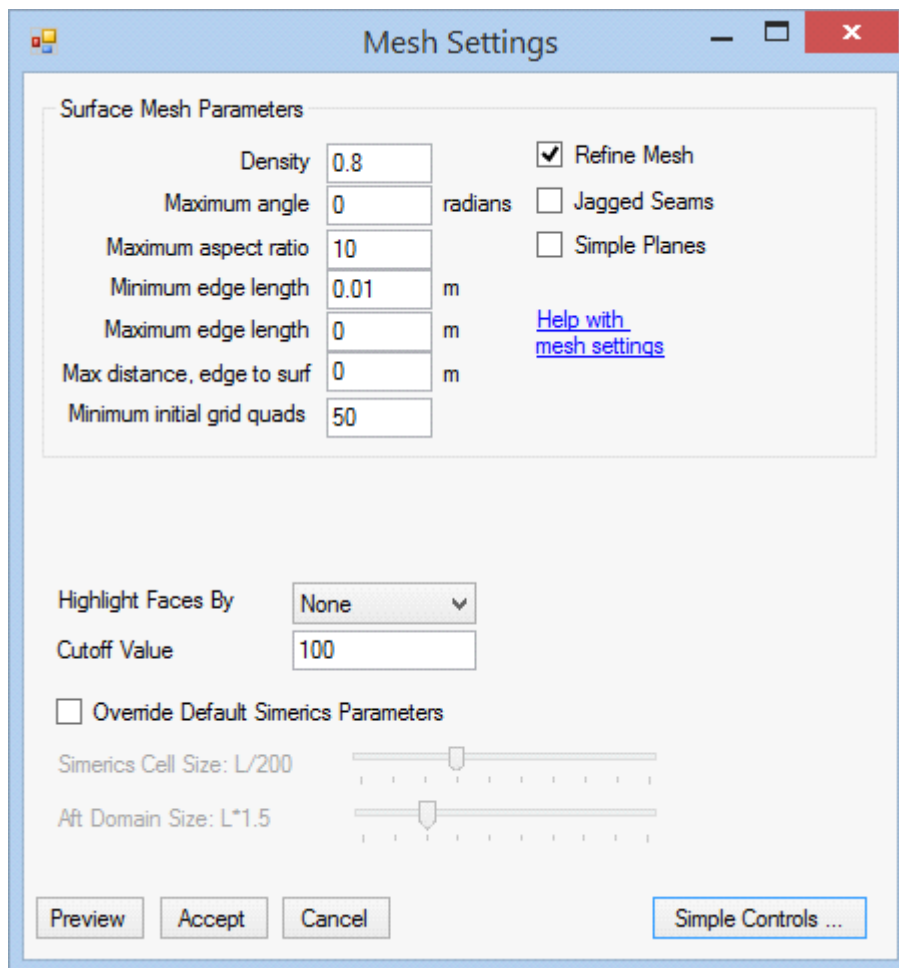
449

Adjusting the Surface Mesh: Sometimes it is necessary to adjust the Rhino mesh before creating the .stl files, to improve the quality of the CFD mesh that is generated in Simerics MP. There are two aspects to the creation of the CFD mesh. The first is the quality of the Rhino mesh, which is characterized by the same parameters as other Rhino meshes (e.g., the rendering mesh, Orca3D hydrostatics mesh, etc.). The parameters include things like Maximum Aspect Ratio, Minimum Edge Length, etc. This is controlled by a slider bar from Fewer Polygons to More Polygons (Simple Control),

or by clicking on Detailed Controls and setting them directly. Click Preview Mesh to see the results of any changes. You can study the quality of the Rhino mesh based on Aspect Ratio and Area. Select one of these parameters, and enter a value. All mesh panels which exceed the entered Aspect Ratio, or are less than the entered Area will be highlighted in yellow.

An ideal mesh would have a uniform distribution of triangle mesh panels with an aspect ratio of 1. Of course this is not possible with anything but the simplest of geometries, but the concept still serves as an objective as you adjust the mesh. You should avoid/minimize the number of mesh panels with extremely large aspect ratios (e.g., greater than 100) or extremely small areas, as well as avoiding abrupt changes in area or aspect ratio between adjacent panels.





Guidance for the Rhino mesh when using Detailed Controls is given below. Also see the “Polygon Mesh Detailed Options” section in the Rhino Help file for more information.

Maximum Aspect Ratio: Try to keep the aspect ratio of most of your panels below 10.

Min Edge Length: This should be at least as large as the Minimum Cell Size in Simerics MP. Use 1 cm as a starting point.

Max Edge Length: This can be used to help avoid high aspect ratio panels. However, setting it too low will result in a very large mesh and can significantly increase the time required to perform the CFD simulation.

Minimum Initial Grid Quads: Start with 50, and increase as necessary.

The second aspect to creating the CFD mesh includes parameters that Simerics MP uses to generate the CFD mesh from the Rhino mesh. These are characterized by the minimum cell size, the maximum cell size, the Hull cell size (used for the Hull and Transom surfaces), the surface cell size (used for the Deck surfaces), the Wave Refinement Zone cell size, and the Domain Size aft of the vessel. Simerics

MP has default values for these parameters, or you can choose to override them if you find that the default mesh is not adequate or is too fine. In that case you can change the "Simerics CFD Mesh Size." Choices include Coarse, Medium Coarse, Normal, Medium Fine, Fine, Extra Fine (this can also be changed in the Simerics interface). It is good practice to run your model at least once during your project with different settings and to compare the results. This "mesh study" will allow you to be confident that your mesh is fine enough to give you good results, without being too fine and causing long run-times.

13.2.3.8 Starting the Simulation

Running the Simulation: Once all of the steps above have been completed, you are ready to run the CFD analysis by clicking on the Run Simulation button. When you click on this button, the .stl, .spro, and .spsd files are created. You are then prompted to select which .spro file you would like to run (if you have entered multiple speeds or multiple RPMs, you will have a .spro file for each one and each one is run separately in SimericsMP). The SimericsMP executable will then be started with that .spro file (note: you must enter the path to the *Simerics.exe* file in the Simerics tab of the Orca3D Properties dialog).

If you check the "Create Run Files Only" box, the .stl, .spro, and .spsd files will be created, but the SimericsMP executable will not be started. Then you can start SimericsMP and load the .spro file for the simulation that you wish to run.

13.3 Running the Simulation in Simerics MP

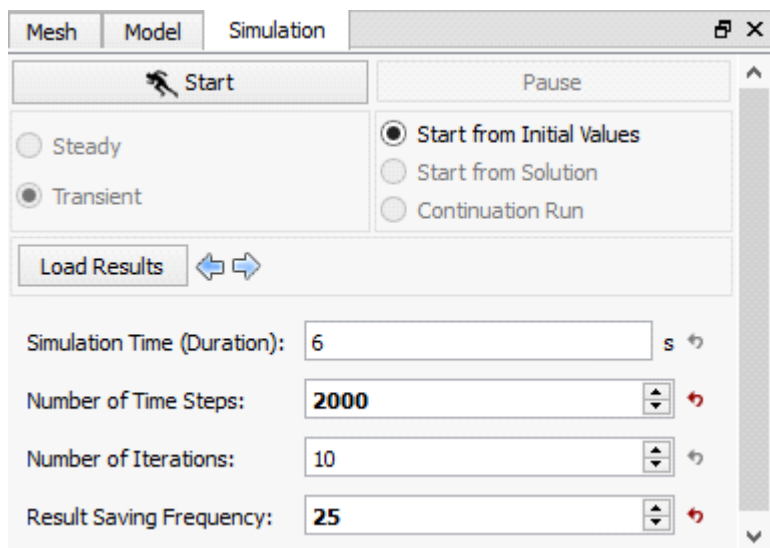
Once the model has been set up in Orca3D and the files have been created (.spro, .stl, and .sdsp) you are ready to run the simulation in SimericsMP. The following sections guide you through the process.

13.3.1 Starting, Pausing, & Restarting a Simulation

Starting a New Simulation

Once you have started Simerics MP, open the .spro file that you wish to run (if it wasn't loaded automatically by launching from Orca3D). You will immediately see messages as the CFD meshes are created, and you will see two views of your model boundaries and the free surface.

Select the "Simulation" tab if it is not already selected, and if you are satisfied with the default parameters, click the Start button in the Simulation panel.



The run parameters are defined as follows (note that you can Stop a simulation and change these parameters, and then continue the run):

Simulation Time: Number of seconds of simulation time. This time should be long enough for the vessel to traverse the length of the domain enough times to reach a steady state condition. In practice, there is no harm in setting this number too high. Typically, the simulation should be run until you see that the results have converged. If the simulation time is reached but the results indicate that a steady state condition has not been reached, you should continue the simulation.

Number of Time Steps: One of the conditions (known as the Courant-Friedrichs-Lewy or CFL condition) that govern the size of the time step used in numerically solving partial differential equations such as the Navier Stokes equations, is that it should be small enough that a fluid particle does not completely traverse a cell in a single step. Practically speaking this condition, defined by a “Courant number” of 1, cannot typically be met throughout the entire fluid domain. Most CFD solvers, including that used in Simerics, are robust enough to remain stable for much larger Courant numbers. But it does imply that there is an upper limit on the size of the time step used to reach a stable and converged solution and also implies that the finer the CFD mesh, the smaller the time step (and the larger the number of time steps for the specified simulation time). The time step is computed by dividing the simulation time by the number of time steps. Setting the number of time steps too high will simply make the analysis take longer; setting it too small will cause an error (Courant Number error). If you get this error, increase the number of time steps and continue the run.

Number of Iterations: There are multiple iterations in each time step. There must be enough iterations for the solution to be resolved in each time step. As the vessel is accelerating, the guidance is set this value to 10. Later, as the vessel approaches equilibrium, you can pause the simulation and it can be adjusted to 7, or even as low as 5. Again, there is no harm in leaving it too high, except that the analysis will take longer to complete. If this value is too low, the results will become unstable and diverge.

Result Saving Frequency: Interim results are saved for a couple of reasons. First, an analysis can be stopped at any time, and restarted later from interim results. Second, the interim results are used to post-process and generate animations (.gif files) of the run. Each set of results is a single frame in the animation, so the more sets of interim results you have, the smoother your animation will be. The Result Saving Frequency is measured in time steps. For example, if you have 2500 time steps and a saving frequency of 25, you will have 100 sets of interim results. The only downside to setting this value too low is that it will use a lot of hard disk space (often 200-300 MB per set of results).

Pausing a Simulation

Since the CFD analysis will use as much of your computer’s resources as available, there may be times when you wish to temporarily pause the simulation, by clicking on the Pause button. To restart the simulation, click the Pause button again.

Stopping and Restarting a Simulation

To stop a simulation, click the Stop button. If the results have not been saved recently, you will be asked if you want to stop the simulation after the next set of results are saved.

You can restart a simulation, either from the initial values or as a continuation of a previous run. To start from initial values, either re-load the .spro file, or click on the "Start from Initial Values" radio button. To continue a previous run, you must first load a results file (.sres). Click on the Load Results button, and select the appropriate .sres file (usually the most recent one). Then click the Start button.

Note: Any time that you Start a simulation, even if it is a Continuation Run, the Simulation Time, Number of Time Steps, Number of Iterations, and Result Saving Frequency all apply from that point forward. For example, if you load a results file that represents 4 seconds of simulation time, and your Simulation Time is set to 10 seconds, when you start the Continuation Run the total duration will be 14 seconds.

13.3.2 Monitoring & Generating Output from the Simulation

13.3.2.1 Three-Dimensional Graphical Output

13.3.2.1.1 Plotting Results on the Surfaces

Plotting Results on the Surfaces

To show results such as pressure on the surfaces:

1. In the Geometric Entities panel, select the desired surfaces (for example, hull, deck, and transom). Click on the names to highlight each one, holding the CTRL key for multi-select. The surface names should be checked and highlighted in blue.
2. In the Results panel, use the Variable drop-down list to select the parameter that you wish to plot (e.g., Marine Dynamic Pressure). Note that you can enter the Min and Max values for the range of colors.
3. In the same way, Free Surface Elevation can be shown on the Derived Surface called "Free Surface Elevation."

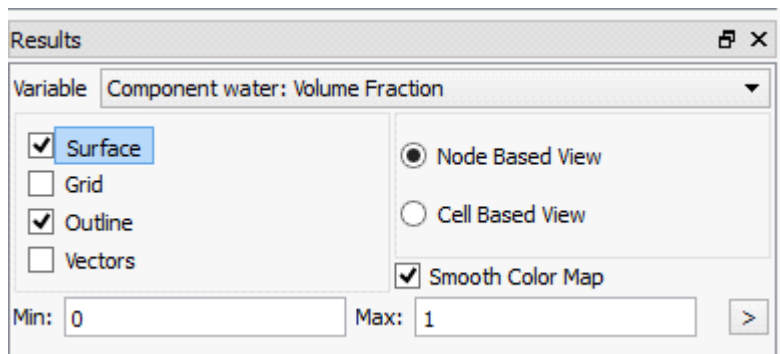
If you wish to see data at a cross section, you can add more Derived Surfaces.

1. In the Geometric Entities panel, click on the Create a Cross Section icon
2. Select your new Cross Section under Derived Surfaces
3. In the Properties panel, select the Geometry tab. Select the Type (Plane X, Plane Y, Plane Z, Arbitrary Plane), and the Position.
4. In the Results panel, select the Variable to be plotted on the cross section.

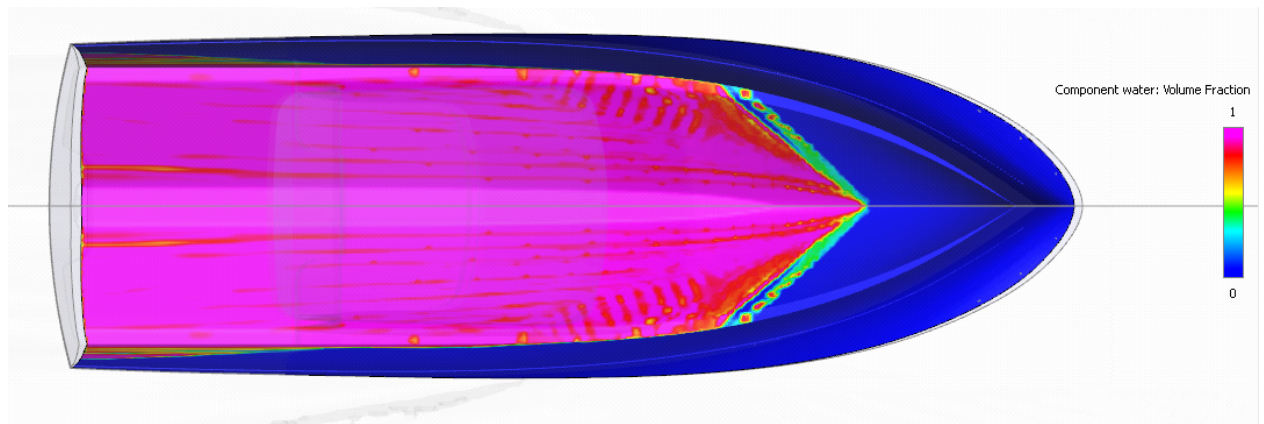
13.3.2.1.2 Checking your CFD Mesh

Checking Your CFD Mesh

One method to determine whether your CFD mesh is fine enough is to look at the Volume Fraction of water along the Hull and Transom boundaries. The Volume Fraction of water should be close to 1 (1 is 100% water, 0 is 100% air). To do this, select the Hull boundary from the Geometric Entities panel. Then in the Results panel, select Component Water: Volume Fraction from the Variable drop down list.



A false color map of the Volume Fraction on the Hull boundary will be shown:



As shown in this image, the bottom is mainly 100% water, with a few “streaks” of water/air mixture as would be expected. At the spray root, there is the expected transition from 100% air to 100% water. If your hull is showing large areas of orange, yellow, blue, or green where you would not expect air, then your results are likely not valid, and you may need to adjust your mesh settings.

13.3.2.1.3 Plotting Streamlines

Plotting Streamlines

You can plot flow streamlines along the Hull, Transom, and/or Deck. The simulation must be complete, and the results must be loaded (note that if you are plotting streamlines after loading results from a past simulation, you have to run one time-step to get the streamlines). To display streamlines, follow these steps:

1. If the simulation is running, click Stop in the Simulation tab. If you using a previously run simulation, use the Load Results button to load the results file.
2. In the Model panel, click the Select Modules button. Select Streamline, and then click Add and then Close.
3. Re-start the simulation by clicking the Start button in the Simulation tab. You must run at least one time step after adding the Streamlines module in order to see results (otherwise you will see nonsensical streamlines). You can stop the simulation after running one complete time step if you wish.
4. In the Model panel, select the Marine module (not Streamlines)
5. In the Geometric Entities panel, select the boundary or boundaries (Hull and Transom for water streamlines, Deck for air streamlines)
6. In the Model Properties tab, under Streamline, change
 - a. Release Particle to Yes
 - b. Direction to Both
 - c. Number of Particles to 50 (you will want to experiment with this setting)
7. Select Streamline in the Geometric Entities panel
8. In the Model Properties panel, enter the Line Thickness, Animation Time Size, and Maximum Integral Steps. The Animation Time Size is a multiplier on the local velocity; e.g., a value of 2 will have the streamlines flowing at 2 times the local velocity.
9. In the Results panel, select a Variable (usually Velocity Magnitude) from within the Derived Variables list
10. In the Geometric Entities panel, select the entities that you wish to see in the display window; for example, the Deck, Hull, and Transom boundaries, the FreeSurface, and the Streamlines.
11. If you want to change the properties of the Streamlines, select Streamlines in the Geometric Entities panel, and then in the Model Properties tab you can vary the Number of Particles, etc.

13.3.2.1.4 Adding Text to the View

Adding Text to the View

If you want to add text to the view (perhaps so that it will be shown in a saved image or animation), follow these steps:

1. In the Properties panel, select the View tab.
2. Click on the arrow next to Global Parameters
3. Click on Text Label, and enter your text
4. You will now see entries for Position, Font, and Color, which you may adjust.
5. If you wish to add another text label, click on the next Text Label entry (below the one that you just created)

In addition to adding text, there are various parameters which you can add. For example, if you want the RPM to be shown, you can enter

RPM={prpm1}

The {} indicate a parameter. In this example and the ones below, the "1" indicates the first propeller; use "2" for the second propeller, and so on. Other parameters than can be used include:

For all runs:

Parameter	Text
Velocity (m/s)	{marine.forward_vel}
Heave (m)	{trans_1d.marineHeave.displacement}
Pitch (radians)	{rotate_1d.marinePitch.angle}

For powered runs:

Parameter	Text
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Advance Coefficient	{marine.prop_J1}
Thrust Coefficient Kt	{kt1}
Torque Coefficient Kq	{kq1}
Thrust (N)	{marine.prop_T1}
Torque (N-m)	{marine.prop_torque1}
Delivered Power (W)	{marine.prop_power1}

The values displayed are in the SI unit system. If you want different units, you can add a conversion in the expression. For example, to display the velocity in knots, enter {marine.forward_vel*1.94384}. You can also add a formatting statement. For example, if you wanted the Pitch in degrees, as a floating point value with places after the decimal, use Pitch={rotate_1d.marinePitch.angle*57.3%3f} degrees.

13.3.2.1.5 Exporting Distributed Pressure Data

Exporting Pressure Data

The pressure information that is displayed on the hull boundary (or any other boundary) as a color map can be exported to a text file, with a list of X, Y, Z locations and the pressure at that point. The file is saved each time a .sres file is saved (according to the Results Saving Frequency).

! pressure distribution at patch hull [N/m2]

P	X	Y	Z
14.382	-3.2823	-0.913877	8129.26
14.382	-3.31444	-0.913877	8129.26
14.3557	-3.2823	-0.91491	8139.64

14.3557 -3.31443 -0.91491 8139.64

To have this file created, follow these steps:

1. Click on the Marine module in the Model tab of the main pane
2. In the Properties pane, go to the Model tab, and change Setup Options from Template Mode to Extended Mode
3. In the Geometric Entities tab, click on the boundary (e.g., hull; click on the word, not the check box. You want it to be highlighted in blue)
4. In the Properties pane, go to the Model tab. In Flow -> Mixture, change Output to User Select, and change Pressure Distribution to Yes.

If the simulation is currently stopped, you will have to run it again to a point where it saves a .sres file.

13.3.2.1.6 Saving Animations and Images

Saving Animations and Images

Simetrics can create a time-based GIF or PNG animation of the analysis run, using the results files (.sres) that were stored during the analysis. Each .sres file will represent one frame in the animation. Follow these steps to create the animation:

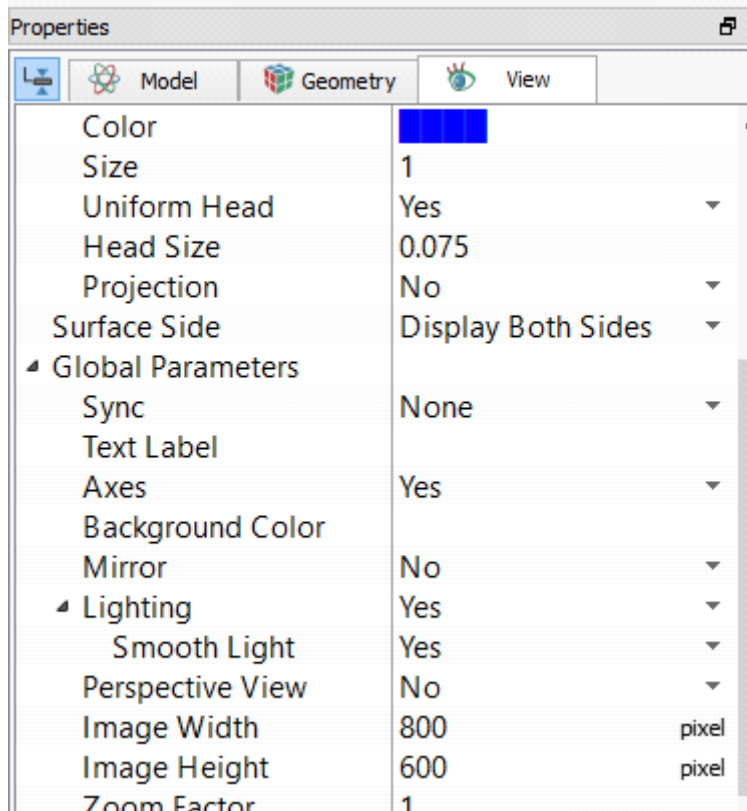
1. Load the .spro file
2. Orient the view for the animation
3. In the File menu, select Save Animation
4. Select the .sres files to include
5. Select the file type (.gif or .png) and enter the filename for the animation

Because the view in the window may not be the same 4:3 aspect ratio that is used in images and animations, the result may not match your window exactly. It's a good idea to first save a single image to be sure that you're happy with the view, before saving the animation (because the animation can take a few minutes to create, depending on the speed of your hard disk and processor).

To save an image, in the File menu click on Save Image and enter the file. The image will be saved as a PNG file.

To play back an animation, load the file into a program such as Internet Explorer or Chrome. The animation will play at whatever speed your software will display it. If you want to change the speed, load it into a video editing tool such as Windows Moviemaker, Gimp, or Camtasia, where you can set the playback speed and save the file in a format such as .mov or .mp4.

The default resolution of the animations and images is 800x600. You can change this by clicking on the View panel, and then Global Parameters, and setting the Image Width and Image Height. You can also place text on the image, by entering a Text Label.



13.3.2.1.7 Exporting the Free Surface

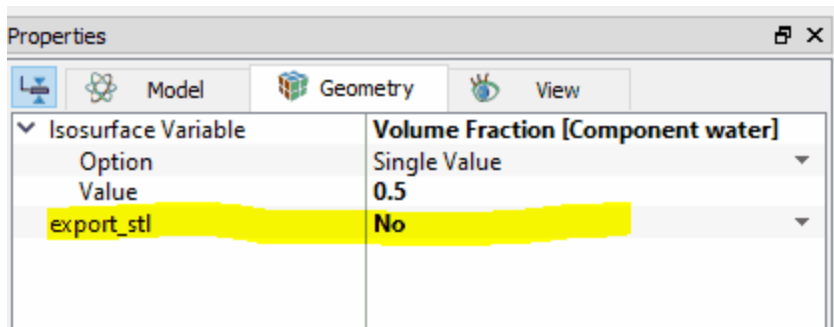
The free surface may be exported to an STL file, which can be used in Rhino/Orca3D for rendering the model underway. The OrcaCreateNewRender command will both read the STL file, and orient the model at the correct Pitch and Heave values so that the model is positioned correctly within the free surface.

To export a free surface, you will need Simerics-MP version 5.0.16 or later.

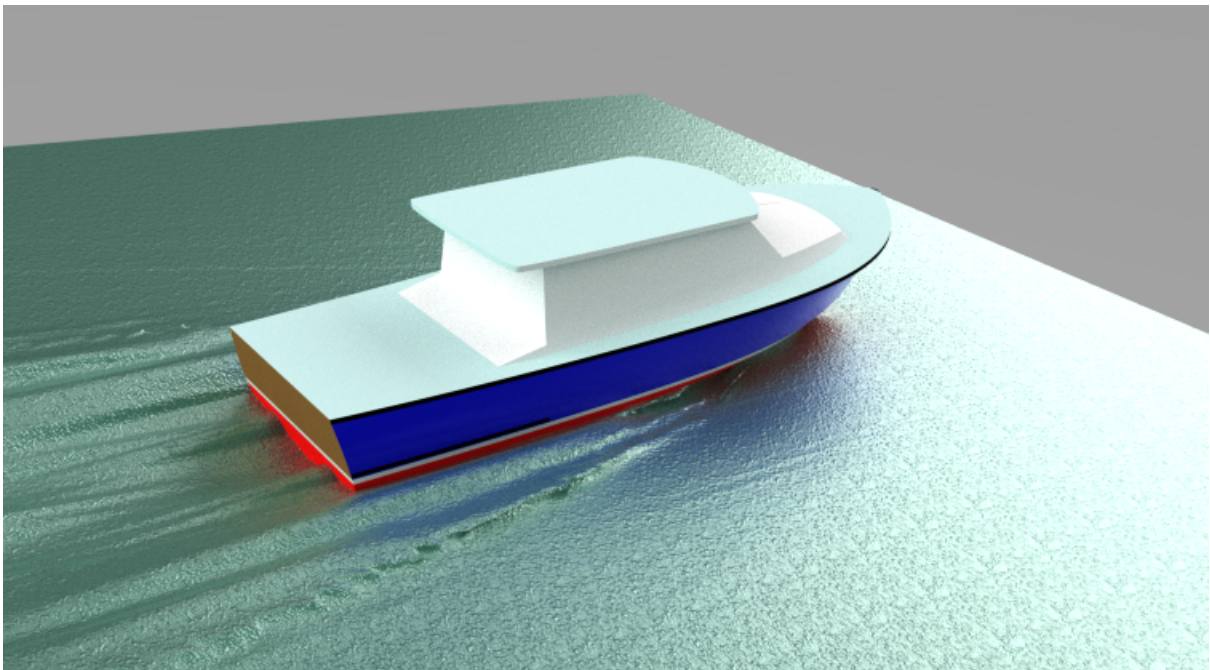
Follow these steps to export the free surface:

1. Open a simulation in SimericsMP and load the latest results file
2. In the Geometric entities window select the free surface
3. In the Geometry tab of the Properties panel you will see a new entry called "export_stl"

as shown below. Click the dropdown that says No and click Yes. This action causes a file to be written to the Simerics simulation folder called "FreeSurface_phasecomp.water.vFrac.stl". This is the STL file representing the free surface mesh.



Now, in Rhino/Orca3D, type the command OrcaCreateCFDRender and follow the prompts. Note that the model that you use for rendering in Rhino doesn't need to be exactly the same model that you used for the CFD analysis. For example, if you used a simplified model for CFD but you have a very detailed model for construction/rendering, you can use the detailed model here. The OrcaCFDRender command will orient the selected geometry according to the heave and pitch from the CFD analysis.




13.3.2.2 Two-Dimensional Time History Data

13.3.2.2.1 Plotting Marine Specific Data

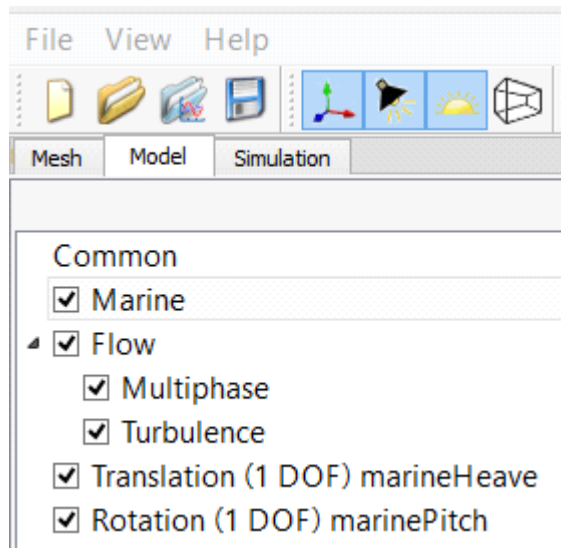
Plotting Marine-Specific Data



The results of the simulation may be plotted during or after a run. Follow these steps to set up the plots before, during, or after a run (if you want to come back to a previous run and plot the data, load the .spro file and then use the Load Results button to load the latest results (.sres) file).

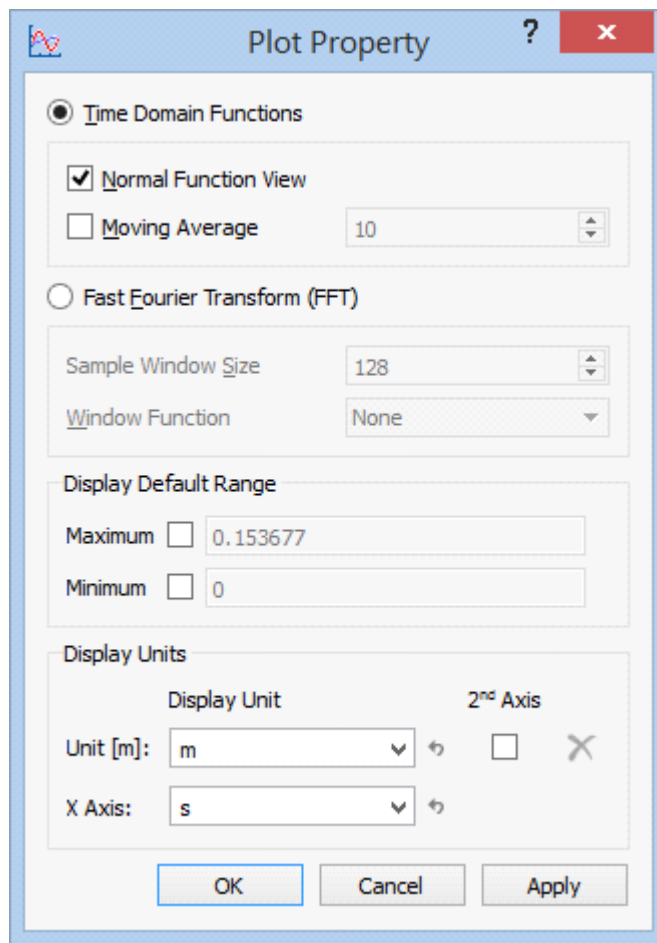
1. Click the Add XY-Plot icon, or select Add XY Plot from the View menu.
2. Select the new plot tab (e.g., Plot 1), and click on the Variable list icon along the left side of


the plotting window ().

3. In the Model panel, click on Marine, so that it is highlighted:



4. You will see a list of available data to plot, shown to the left of the plotting area. Select a value, and click on the Plot Selected Variable icon ().
5. You may plot multiple values on the same plot. For example, it's useful to plot Heave and Pitch, and monitor these values to see when they have converged.
6. To change the units, click on the Plot Property icon (). In this dialog you can select your units, and if desired change the plot to be a moving average rather than the normal function view (this is mostly useful when you are ready to export the results to Excel).





7. To zoom to an area on the plot, simply drag a box around the area. To reset to the full view, double-click the plot area. To pan the view click and drag with the right mouse button.
8. To export the data to Excel, click the Copy Data icon (). The data for this plot will now be on your clipboard, ready to be pasted into a spreadsheet.

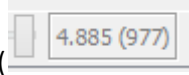
You can add as many plots as you like; for example, you might have one plot to show Forward Velocity, one to show Heave and Pitch, and one to show EHP. It's useful to have one plot that includes Heave, Pitch, and EHP; even though the scales are very different and so visually it isn't very useful, it makes it easy to export all of the data at once to a spreadsheet.

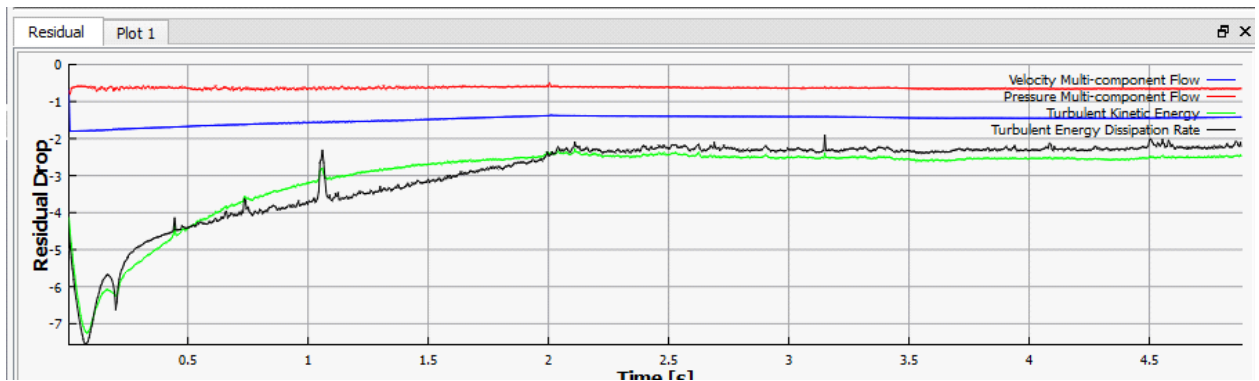
To plot values that are not marine specific (e.g., shear and pressure force), follow these steps:

1. Select the Boundary on which you want to see the data, in the Geometric Entities panel. For example, in the tree under the Boundaries entry, select the Hull, Deck, and Transom (hold down the CTRL key to do a multiple select).
2. Click the Add XY Plot icon, and select the plot tab for the plot that you just added (e.g., Plot 2)

3. Click the Variable List icon to the left of the grid
4. Select Pressure Force X. If you have selected multiple boundaries (i.e., Hull, Deck, and Transom in this example), you can select to plot the sum of the Pressure Force X for all three boundaries by clicking on the Combine Entity Data into a Single Curve icon ().
5. Do the same for the Shear Force X.
6. To see the wetted surface, select Phase Area as the variable to be plotted.

There is always a Residual Plot, showing the residual drop for each iteration within a time step. By default, this plot only shows a single time step. To see the residual for the entire run, click the green arrows icon in the lower right corner (). Note that to the left of this icon you will see an

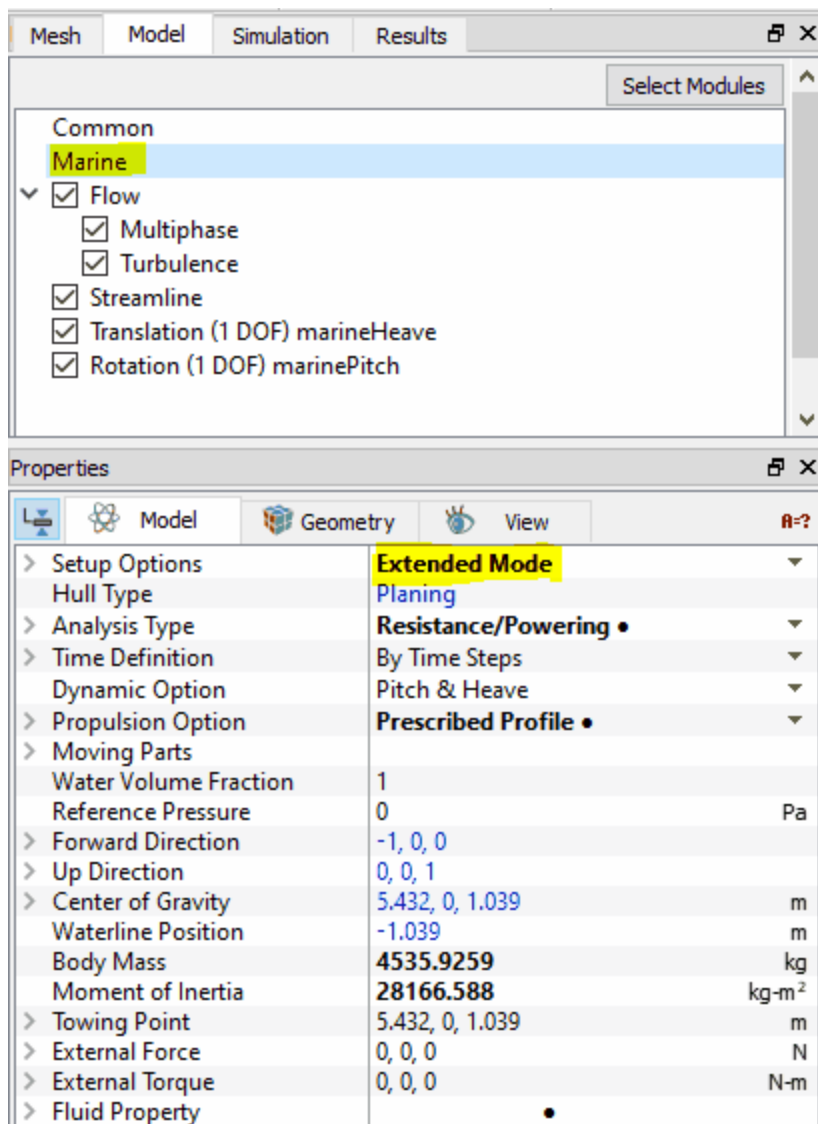
indication of the number of seconds and number of time steps so far in the run (). You will typically see the residuals level out over time.



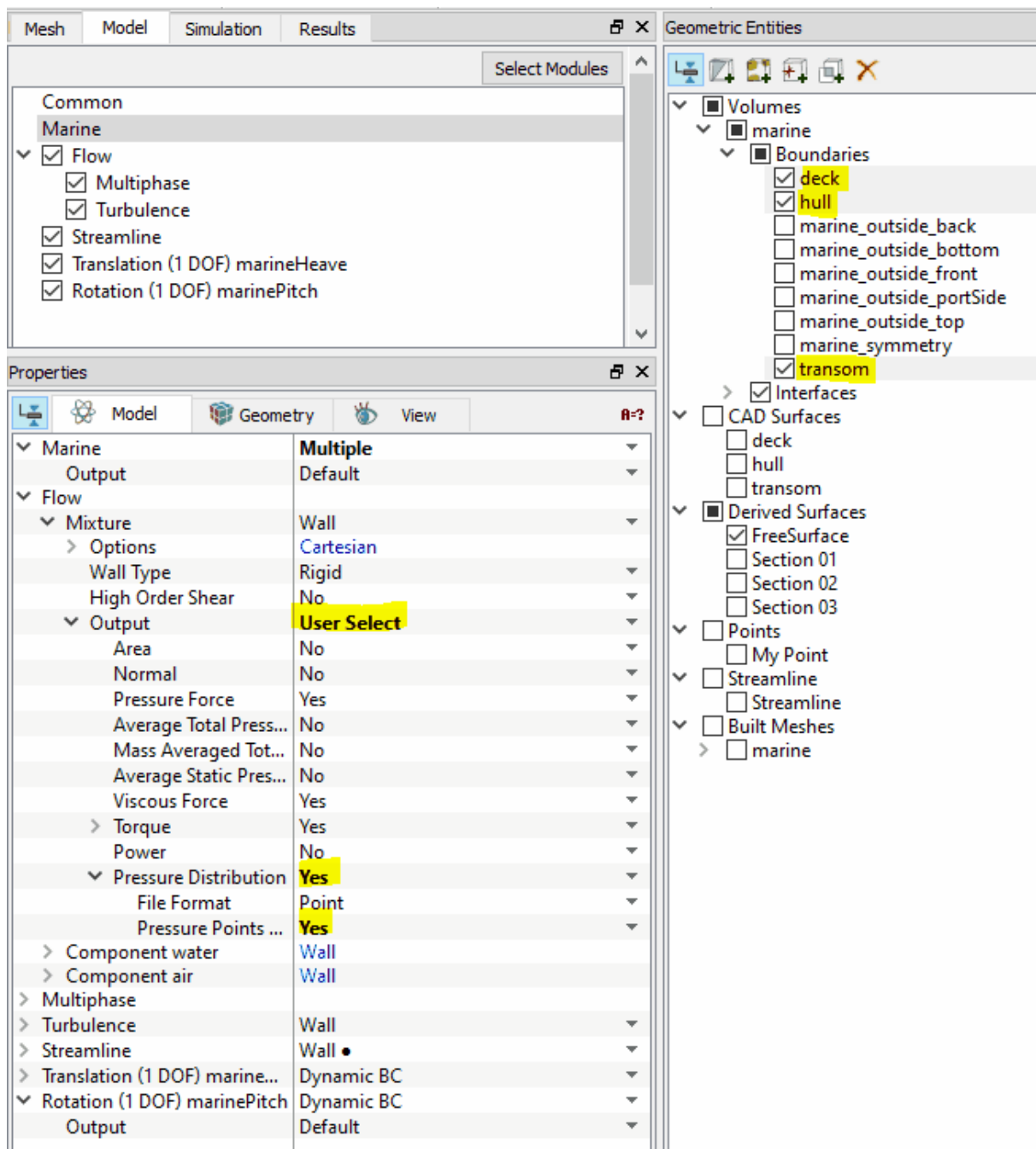
13.3.2.2.2 Plotting Integrated Pressures on Surfaces

Orca3D Marine CFD can export the dynamic pressure distribution over any boundary in the model. By default this output is turned off. To turn it on do the following:




























1. In the Model panel, select the "Marine" module as shown below. Then in the Properties panel change the "Setup Options" from Template Mode to Extended Mode.



2. Now select the boundaries for which you want pressure distribution information in the Geometric Entities panel as shown below. Here we selected "deck", "hull", and "transom." Then in the Properties panel, under the Flow > Mixture item change Output from Default to User Select. Finally, change "Pressure Distribution" from No to Yes and Pressure Points Connectivity to Yes.



3. After saving this you can run the simulation. The program will create text files for each of the boundaries that you enabled pressure distribution output, as shown below. These files will be saved at time steps corresponding to the Results Saving Frequency value that was set for the simulation. For example if you set the Results Saving Frequency to 100, then the pressure distribution text files will be saved every 100 time steps.

 Eastport 32 Appended with Superstructure_25kt.out	10/4/2019 2:05 PM	OUT File	0 KB
 Eastport 32 Appended with Superstructure_25kt.sdsp	9/27/2019 8:09 AM	SDSP File	6 KB
 Eastport 32 Appended with Superstructure_25kt.sgrd	5/28/2019 5:53 PM	Simerics Grid File	183,837 KB
 Eastport 32 Appended with Superstructure_25kt.spro	9/14/2019 9:08 AM	Simerics Project File	4 KB
 Eastport 32 Appended with Superstructure_25kt_integrals.txt	10/4/2019 2:06 PM	Text Document	9,282 KB
 Eastport 32 Appended with Superstructure_25kt_points.txt	10/4/2019 2:06 PM	Text Document	1,993 KB
 eastport32_wave_00100.sres	9/13/2019 8:01 AM	Simerics Results File	1,116,205 KB
 eastport32_wave_00100_deck_connections.txt	9/14/2019 11:00 AM	Text Document	167 KB
 eastport32_wave_00100_deck_pressure.txt	9/14/2019 11:00 AM	Text Document	360 KB
 eastport32_wave_00100_hull_connections.txt	9/14/2019 11:00 AM	Text Document	3,907 KB
 eastport32_wave_00100_hull_pressure.txt	9/14/2019 11:00 AM	Text Document	6,473 KB
 eastport32_wave_00100_transom_connections.txt	9/14/2019 11:00 AM	Text Document	50 KB
 eastport32_wave_00100_transom_pressure.txt	9/14/2019 11:00 AM	Text Document	116 KB
 eastport32_wave_00200.sres	9/13/2019 8:01 AM	Simerics Results File	1,137,060 KB
 eastport32_wave_00200_deck_connections.txt	9/14/2019 11:01 AM	Text Document	167 KB
 eastport32_wave_00200_deck_pressure.txt	9/14/2019 11:01 AM	Text Document	360 KB
 eastport32_wave_00200_hull_connections.txt	9/14/2019 11:01 AM	Text Document	3,907 KB
 eastport32_wave_00200_hull_pressure.txt	9/14/2019 11:01 AM	Text Document	6,473 KB
 eastport32_wave_00200_transom_connections.txt	9/14/2019 11:01 AM	Text Document	50 KB
 eastport32_wave_00200_transom_pressure.txt	9/14/2019 11:01 AM	Text Document	116 KB
 eastport32_wave_00300.sres	9/13/2019 8:11 AM	Simerics Results File	1,148,519 KB
 eastport32_wave_00300_deck_connections.txt	9/14/2019 11:01 AM	Text Document	167 KB
 eastport32_wave_00300_deck_pressure.txt	9/14/2019 11:01 AM	Text Document	360 KB
 eastport32_wave_00300_hull_connections.txt	9/14/2019 11:01 AM	Text Document	3,907 KB
 eastport32_wave_00300_hull_pressure.txt	9/14/2019 11:01 AM	Text Document	6,473 KB
 eastport32_wave_00300_transom_connections.txt	9/14/2019 11:01 AM	Text Document	50 KB
 eastport32_wave_00300_transom_pressure.txt	9/14/2019 11:01 AM	Text Document	116 KB

The text file contents are self-evident as shown below. The pressure file contains point locations on the boundary along with the computed pressure.

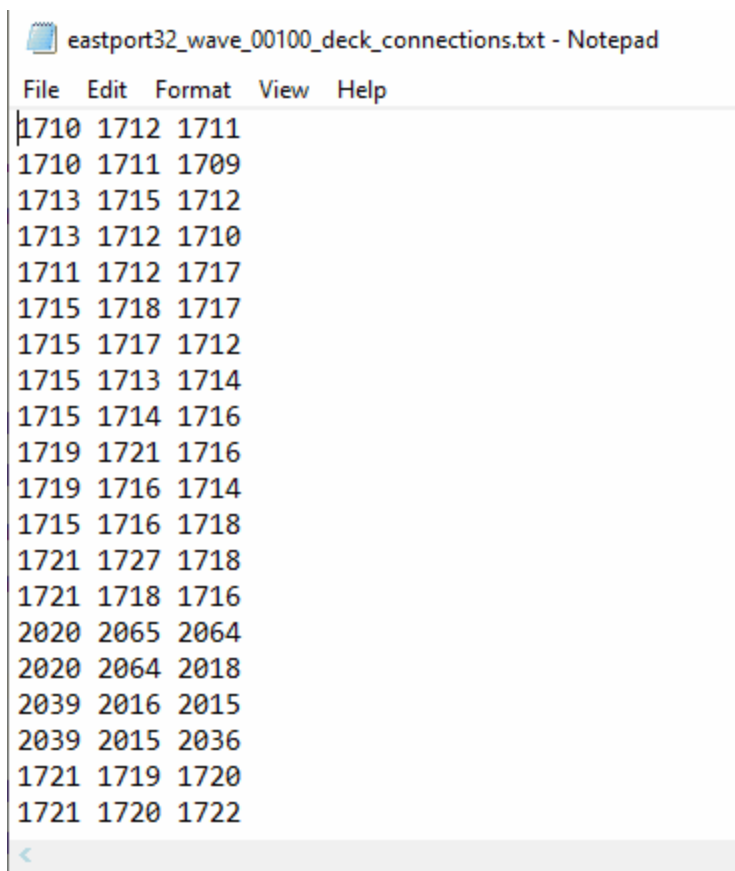
eastport32_wave_00100_deck_pressure.txt - Notepad

File Edit Format View Help

! pressure distribution at patch deck [N/m2]

X	Y	Z	P
2.30277	-0.180148	1.72337	-6.53063
2.30355	-0.186256	1.72308	-6.52708
2.2965	-0.179358	1.72434	-6.54234
2.29847	-0.181329	1.72362	-6.53369
2.29872	-0.186346	1.72338	-6.5308
2.29819	-0.189213	1.72756	-6.58115
9.61262	-0.063071	0.811104	-3.178
9.60464	-0.0315356	0.811377	-3.18129
7.25515	-1.23089	2.15609	-256.202
7.24687	-1.23354	2.16056	-256.256
7.2468	-1.23802	2.16041	-256.254
7.25053	-1.23339	2.16336	-256.29
7.24959	-1.23216	2.16162	-256.269
7.28392	-1.06432	2.17225	-81.8341
7.2857	-1.11261	2.17217	-81.8333
7.25999	-1.08797	2.17324	-81.8461
7.22924	-1.23879	2.16972	-137.045
7.23576	-1.23963	2.16603	-137.001

The connections file contains the connectivity information (i.e., facelist) for the points in the pressure file.

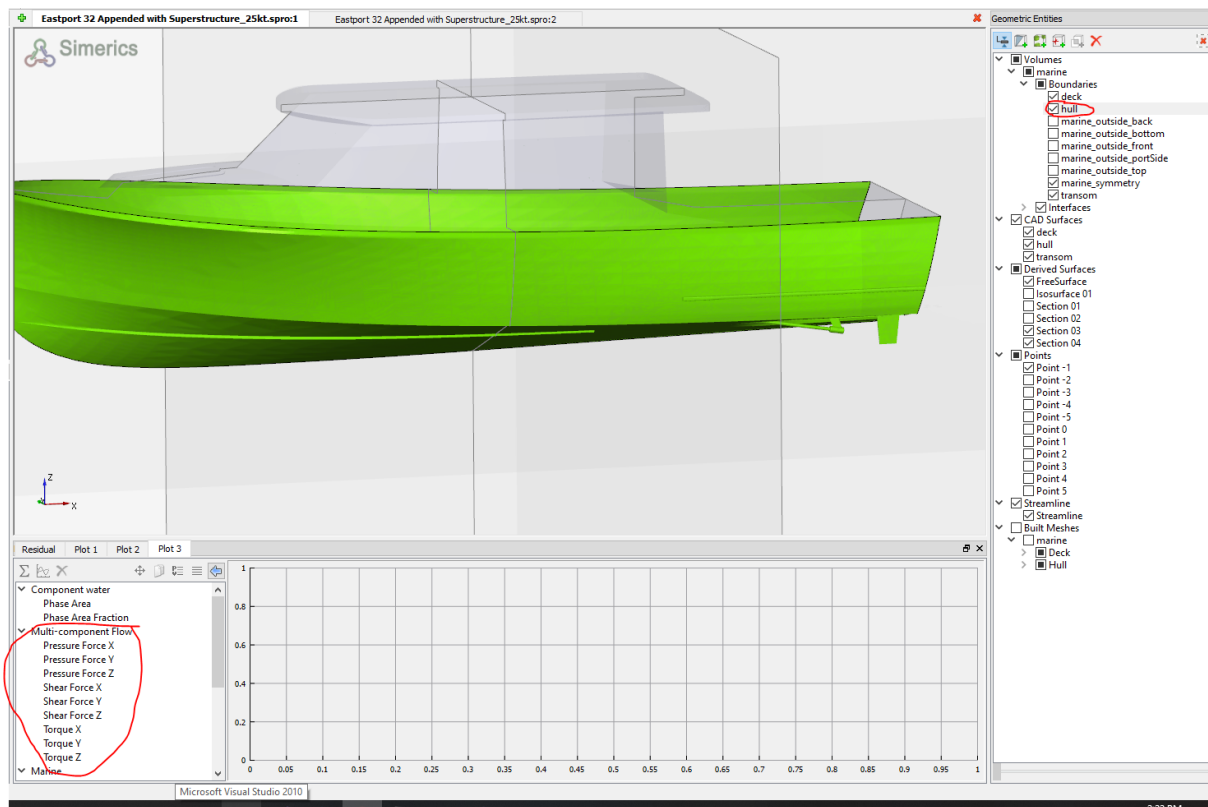


```
eastport32_wave_00100_deck_connections.txt - Notepad
File Edit Format View Help
1710 1712 1711
1710 1711 1709
1713 1715 1712
1713 1712 1710
1711 1712 1717
1715 1718 1717
1715 1717 1712
1715 1713 1714
1715 1714 1716
1719 1721 1716
1719 1716 1714
1715 1716 1718
1721 1727 1718
1721 1718 1716
2020 2065 2064
2020 2064 2018
2039 2016 2015
2039 2015 2036
1721 1719 1720
1721 1720 1722
```

13.3.2.2.3 Plotting Forces and Moments on Surfaces

You can extract forces and moments from the simulation on a "per boundary" basis. For example if everything other than the deck was attributed as "hull" in Orca3D then you can get the forces and moments on the hull. If you attributed the rudder(s) and keel with separate face types in Orca3D, then they will show up as separate "boundaries" in the Geometric Entities window in Simerics MP.

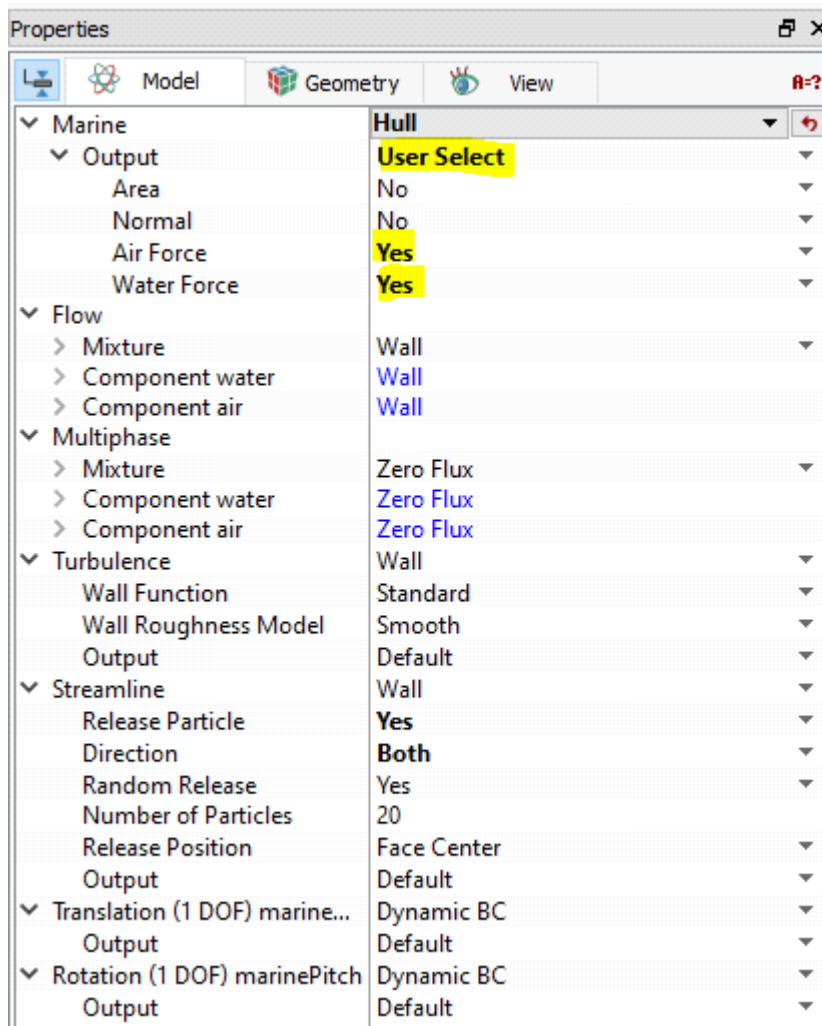
To plot the forces/moments on a specific boundary, first create a new XY-Plot. Then click on the boundary in the Geometric Entities tab, e.g., "Hull" in the example below. As you see in the image you can plot pressure force, shear force, and torque (same as moment). By default the torque is measured about the center of gravity, but you can change that if needed.



13.3.2.2.4 Air and Water Drag Forces

As part of the marine template, SimericsMP computes the total air and water resistance for the simulation and allows them to be plotted in the X-Y plots. SimericsMP can also compute the air and water forces separately for each boundary in the model (e.g., hull, transom, etc.) and will output them in the *.integrals file and allow them to be plotted, but not by default. To get separate air and water forces for each boundary, several additional output switches need to be activated in SimericsMP as follows:

- Once the model is open in SimericsMP, select one or more marine surface entities from the Boundaries group (excluding the marine outside boundaries).
- Select the “Model” tab in the Properties panel
- Under Marine > Output, change from Default to “User Select”. A drop down chevron will appear to the left.
- Click the chevron and individually set Air Force and Water Force to “Yes” as shown below.
- Repeat this process for other boundaries in the model as needed.



When the simulation is run the output will now include air, water and total force components for each surface in the model. If you were to plot the time histories of the X components of the air and water forces on the boundaries and sum those up you would expect those to equal the reported total air and water resistance that are part of the marine template output (although perhaps missing a factor of two if the simulation is symmetric). What you might find is that they are close but not the same, and that is because the total air/water resistance and “per-boundary” air and water resistance are evaluated in slightly different ways.

The built-in marine template fields for air resistance and water resistance are computed only for portions of the model geometry that is above and below the static waterline, respectively. This is generally in accordance with traditional naval architectural predictions of air drag which do not tend to typically account for things like the shape of the intersection of the free surface with the hull or any air that might be entrained below the free surface.

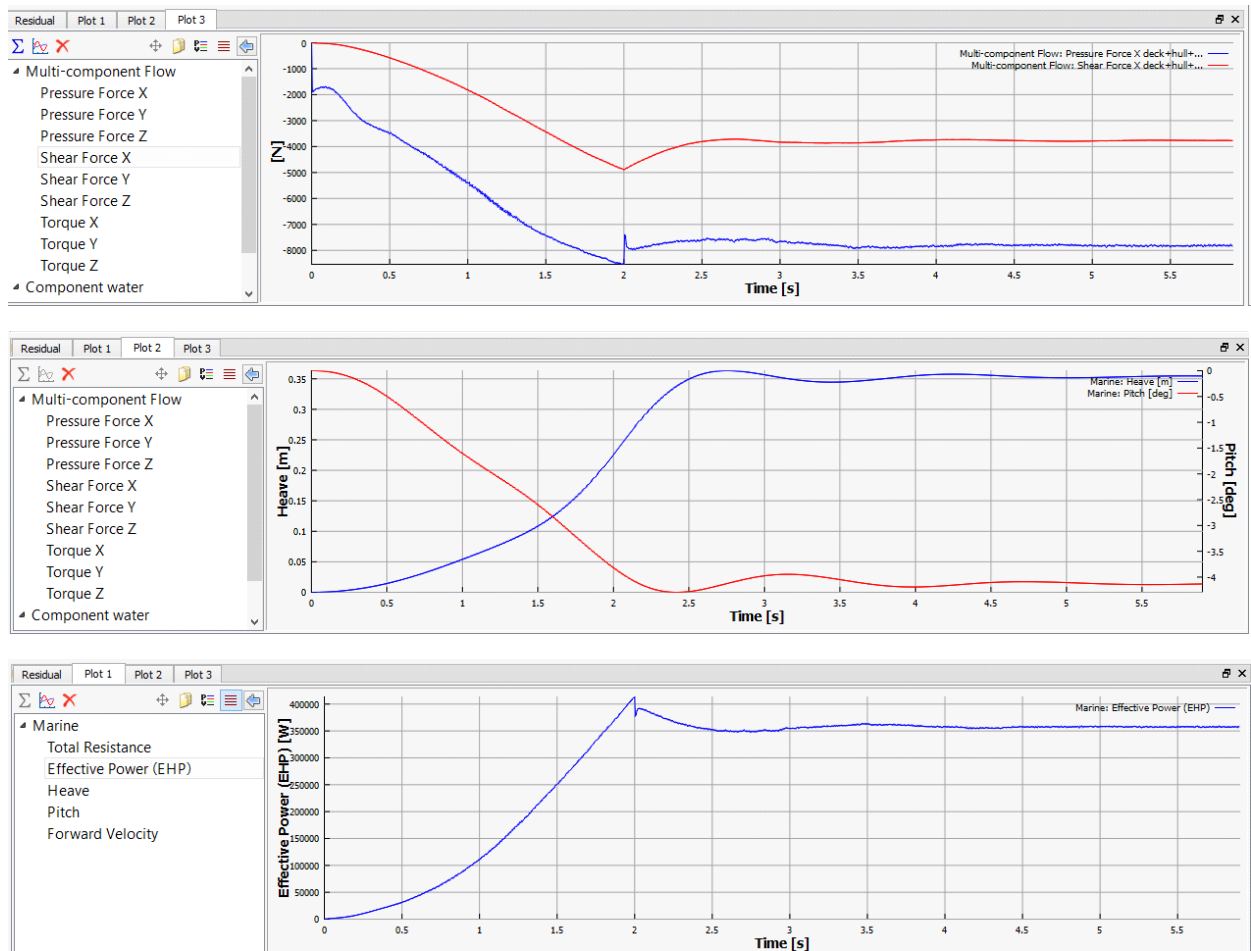
The “per-boundary” air and water drag forces are the integrated values over each boundary (e.g., hull, transom, etc.) regardless of their location relative to the static waterline. So entrained air on the bottom of the hull adds to air drag rather than water drag. Technically

one may say they that the per-boundary values are a more accurate representations of the decomposition of total resistance into air and water components. However, they are not the traditional values that a naval architect might make when performing a prediction and summing drag components. For high-speed planing vessels in particular the decomposed values may depart even more for the two approaches, although the total drag should always be the same. Keep in mind that when running an asymmetric run, the per-boundary air and water forces reported are one-half of the total values. We've left both computations as available values for the user depending on the specific need.

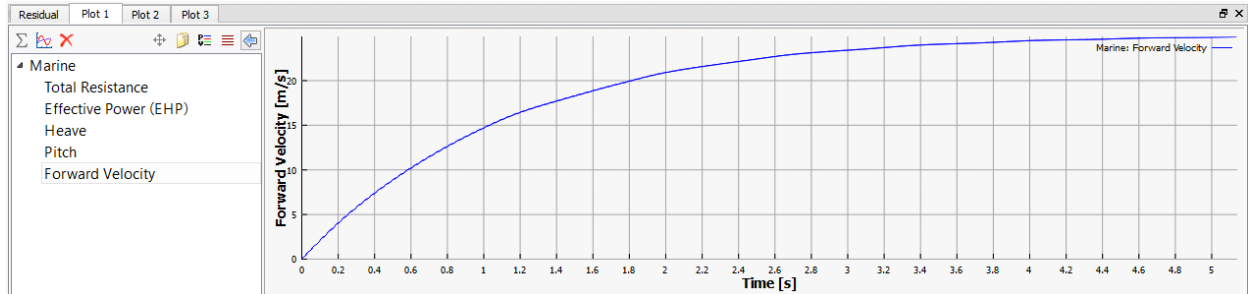
13.3.2.2.5 Convergence of the Simulation

Convergence

The most effective way to know if the analysis has converged is to monitor the Heave, Pitch, and Resistance (or EHP) of Resistance runs, and the Heave, Pitch, and Velocity of Powered runs. When you see that the values are changing very little with time, you are ready to copy the data into Excel. If you see that Pitch and Heave continue to oscillate, your vessel is porpoising. It's also a good idea to look at the Volume Fraction of Water on the Hull boundary.



In this plot of Forward Velocity from a Powered analysis, the model has not yet converged because the velocity is still climbing (this is easier to see if you zoom into the area of the plot in the last few seconds area by dragging a box around it with your mouse):



13.3.2.2.6 Simulation Time History Output Definitions

In addition to [creating a Marine CFD Report](#)⁴²⁵ and [copying time history data to the clipboard](#)⁴⁰⁶, you may also want to look at the time history data that is stored in the `xx_integrals.txt` file (where "xx" is the name of your simulation). This file will be found in the same folder as the project (.spro), grid (.sgrd), etc. files for a particular speed or RPM.

If you have run a Symmetric simulation, it's important to know that some of the values in this file represent the total value (e.g., the EHP is doubled before writing it to the file) and which only represent half of the total. In general, marine-specific values are doubled and more general items (such as the pressure force on a boundary) are not doubled, so only represent the value for one-half of the model (since in a symmetric run, only half of the model is being simulated). In the table below, values that are marked "Yes" would need to be doubled to get the total for a symmetric simulation.

Parameter Title	Half of Total for Symmetric Runs?	Units	Description
time	No	seconds	Time
resistance	No	Newton	total resistance of model
EHP	No	W	Effective Power
resHeave	No	meters	model heave in meters
resPitch	No	radian	model pitch in radian
forwardVel	No	meters per second	model speed in meter per second
airResist	No	N	model resistance from air in newton
waterResist	No	N	model resistance from water in newton
q_marine_outside_back	Yes	kg/s	mass flux through boundary marine_outside_back

q_marine_outside_starboardSide	only reported for asymmetric runs	kg/s	mass flux through boundary marine_outside_starboardSide
q_marine_outside_bottom	Yes	kg/s	mass flux through boundary marine_outside_bottom
q_marine_outside_top	Yes	kg/s	mass flux through boundary marine_outside_top
q_marine_outside_portSide	No	kg/s	mass flux through boundary marine_outside_portSide
q_marine_outside_front	Yes	kg/s	mass flux through boundary marine_outside_front
px_hull	Yes	Newton	pressure force on hull in x direction
px_deck	Yes	Newton	pressure force on deck in x direction
py_hull	non-zero, but a symmetric body would have an equal and opposite force for a net total of 0	Newton	pressure force on hull in y direction
py_deck	non-zero, but a symmetric body would have an equal and opposite force for a net total of 0	Newton	pressure force on deck in y direction
pz_hull	Yes	Newton	pressure force on hull in z direction
pz_deck	Yes	Newton	pressure force on deck in z direction
tx_hull	Yes	Newton	shear force on hull in x direction
tx_deck	Yes	Newton	shear force on deck in x direction
ty_hull	non-zero, but a symmetric body would have an equal and opposite force for a net total of 0	Newton	shear force on hull in y direction
ty_deck	non-zero, but a symmetric body would have an equal and opposite force for a net total of 0	Newton	shear force on deck in y direction
tz_hull	Yes	Newton	shear force on hull in z direction
tz_deck	Yes	Newton	shear force on deck in z direction
torqx_hull	non-zero, but a symmetric body would have an equal and opposite force for a net total of 0	N*m	torque on the hull, rotating about x axis; the torque is about the towing point, which by default is the CG
torqx_deck	non-zero, but a symmetric body would have an equal and opposite force for a net total of 0	N*m	torque on the deck, rotating about x axis; the torque is about the towing point, which by default is the CG
torqy_hull	Yes	N*m	torque on the hull, rotating about y axis; the torque is about the towing point, which by default is the CG

torqy_deck	Yes	N*m	torque on the deck, rotating about y axis; the torque is about the towing point, which by default is the CG
torqz_hull	non-zero, but a symmetric body would have an equal and opposite force for a net total of 0	N*m	torque on the hull, rotating about z axis; the torque is about the towing point, which by default is the CG
torqz_deck	non-zero, but a symmetric body would have an equal and opposite force for a net total of 0	N*m	torque on the deck, rotating about z axis; the torque is about the towing point, which by default is the CG
phase_area_water_hull	Yes	m ²	wetted area on hull
phase_area_water_deck	Yes	m ²	wetted area on deck
phase_af_water_hull	No	-	the fraction(wetted area/whole area) on hull. It is a non-dimensional variable and should be [0,1]
phase_af_water_deck	No	-	the fraction(wetted area/whole area) on deck. It is a non-dimensional variable and should be [0,1]
vD_marineHeave	No	m	displacement in marineHeave direction (world coordinates)
vV_marineHeave	No	m/s	velocity in marineHeave direction
vA_marineHeave	No	m/s ²	acceleration in marineHeave direction
nF_marineHeave	Yes	N	net force
vF_marineHeave	Yes	N	fluid force
sF_marineHeave	Yes	N	spring force
dF_marineHeave	Yes	N	damping force
xF_marineHeave	Yes	N	extra force
angD_marinePitch	No	radian	angular displacement, rotating about marinePitch direction
angV_marinePitch	No	rad/s	angular velocity
angA_marinePitch	No	rad/s ²	angular acceleration
nT_marinePitch	Yes	N*m	net torque; the torque is about the towing point, which by default is the CG
angT_marinePitch	Yes	N*m	fluid torque; the torque is about the towing point, which by default is the CG
sT_marinePitch	Yes	N*m	spring torque; the torque is about the towing point, which by default is the CG

dT_marinePitch	Yes	N*m	damping torque; the torque is about the towing point, which by default is the CG
xT_marinePitch	Yes	N*m	extra torque; the torque is about the towing point, which by default is the CG

13.3.2.3 Monitoring Points

Simerics has an entity called a "monitoring point." Note that monitoring points must be created before running the simulation in order to record data. To create a monitoring point the steps are as follows:

1. On the "Geometric Entities" panel click the icon to create a monitoring point.
2. This will create a new point called "Point 01" under Points in the Geometric Entities Panel. Select Point 01 then click on it again to rename it to whatever you like.
3. Now select the point again and in the Geometry tab of the Properties panel, set the position to the desired location. You can also drag the point with the cursor to a new location using the Select option and the left mouse button.
4. Also set the Type in the Geometry tab as desired to either "Fixed to an Initial Cell", "Stationary", or "Prescribed".
5. By default you should be able to plot the variable you need but if you need to add additional variables, then in the Model tab of the Properties panel, turn on the desired output channels.

Search "Monitoring" in the Simerics v5.0 help file for further details.

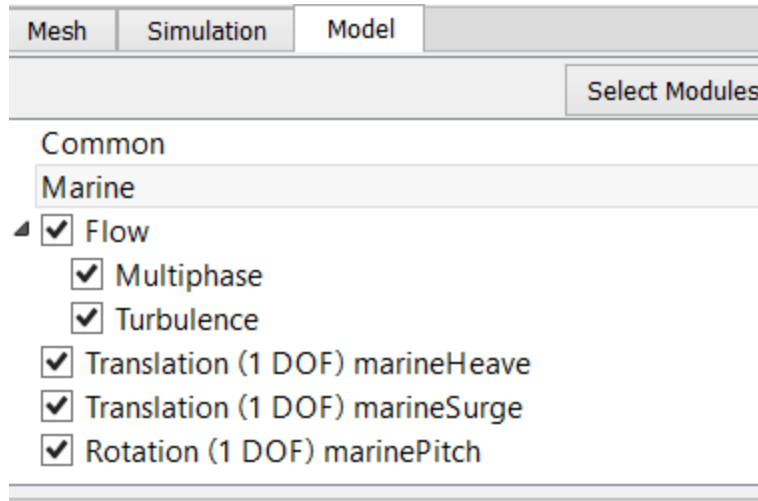
13.3.3 Changing the Tow Point

Changing the Tow Point

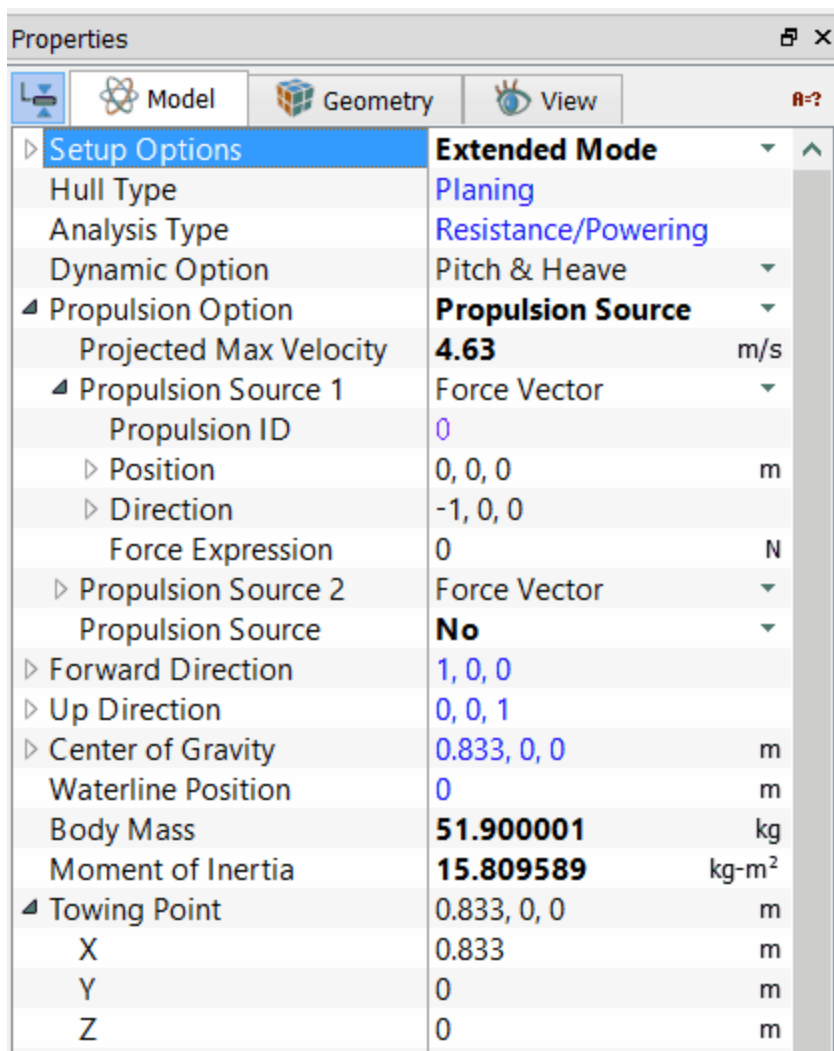
By default, for a resistance run the tow point is located at the center of gravity. The tow point location can be moved, for example to match the tow point of a model test. Because of the large forces and resulting moments involved in the very rapid acceleration during a resistance analysis, we do not recommend that the tow point be moved to the propeller location. A better solution would be to move it vertically to the point where the thrust line intersects the station of the LCG. Alternatively you can run a self-propelled analysis with a propeller (actuator disk) at the propeller location or a thrust vector along the shaft line.

To move the two point location, follow these steps:

1. Select the Marine module in the Model tab

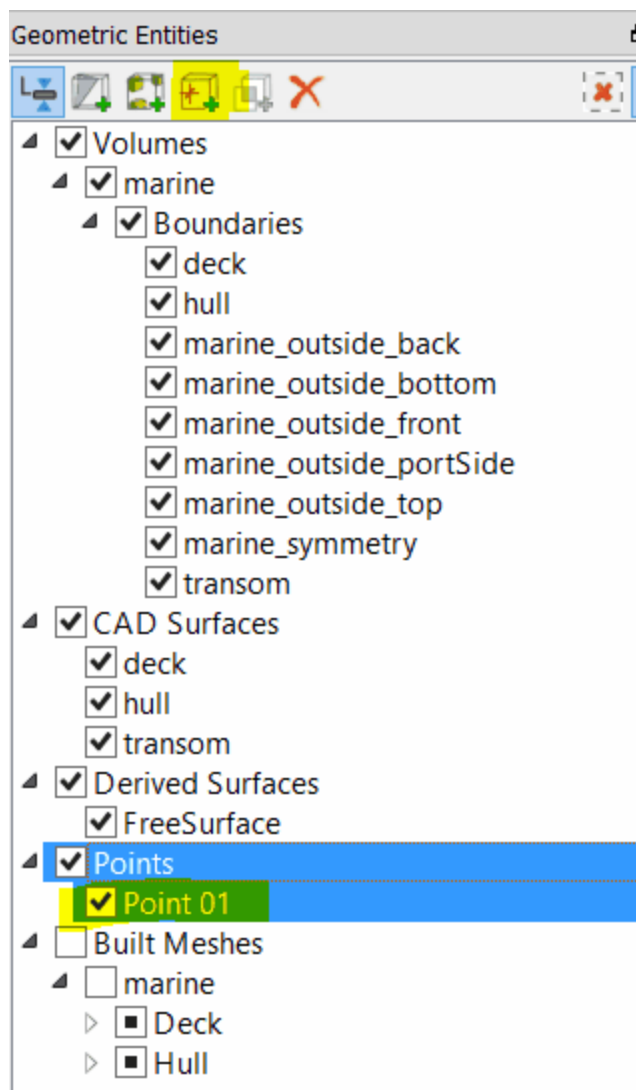


2. In the Properties panel, select the Model tab
3. In Setup Options, change from Template Mode to Extended Mode
4. Scroll down to Towing Point; enter the X, Y, and Z of the center of effort



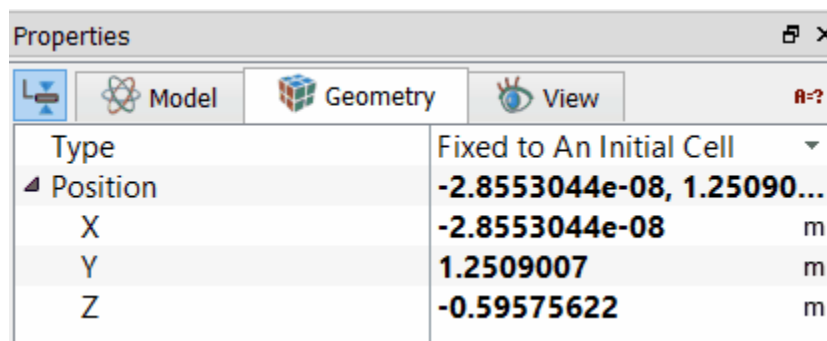
To visually check the location, you can create a Monitoring Point at the same X, Y, Z location:

1. In the Geometric Entities panel, click on the "Create a Monitoring Point" icon image
2. In the tree, click on the new point



3. In the Properties panel, click on the Geometry tab

4. Enter the X, Y, and Z values



13.3.4 Adding or Removing Damping

Adding or Removing Damping

Damping is applied in both Pitch and Heave in all templates (Displacement, High Speed Displacement, and Planing). This allows the solution to converge more quickly, without oscillatory behavior due to numerical instability or excessive pitch due to rapid acceleration. However, it will also mask porpoising behavior. To set up a simulation where porpoising can be detected, you should follow these steps:

1. Run the planing analysis to a converged solution, then stop the analysis
2. In the Model tab (next to the Simulation tab), select the Translation (1 DOF) marineHeave module
3. In the Model tab of the Properties panel, change the Damping Coefficient to 0
4. In the Model tab (next to the Simulation tab), select the Translation (1 DOF) marinePitch module
5. In the Model tab of the Properties panel, change the Damping Coefficient to 0
6. Continue the analysis, and see if the results diverge

13.3.5 Running a Symmetric Analysis with a Centerline Propeller

Running a Symmetric Analysis with a Centerline Propeller

Orca3D Marine CFD allows the user to run simulations with port/starboard symmetry using only one half of the model and domain. This provides a significant savings in computational cost over running the full model. Of course there is also the ability to run the full model, considering both port and starboard sides, to account for any asymmetry in the problem. Sometimes this might be necessary if there is a difference in model geometry between port and starboard sides. However, one case that may not be as obvious is a self-propelled simulation where the propeller is located on the vessel's centerline (e.g., single and triple screw designs). This case is asymmetric because the centerline propeller has a rotational flow component (defined by the propeller rotation direction). When Orca3D creates the CFD simulation files for a self-propelled run it looks at the propeller definition(s) and tries to determine if there is a centerline propeller. If it finds one but the user has chosen a symmetric run, an error message is displayed directing the user to change to an asymmetric simulation. Sometimes, you may be willing to neglect the rotational flow component and consider only the axial flow direction in order to realize the computational cost benefits of a symmetric run. If that is the case you must perform a workaround as follows:

1. First, in Orca3D change the transverse coordinate of the centerline propeller to something other than zero. Pick some value on the port side of the hull. The actual value is not important. This will let you bypass the check on the propeller symmetry.
2. Once you open the simulation in Simerics, set the propeller transverse coordinate back to zero. You can find this by selecting the "Marine" module and in the "Properties" expand the "Propulsion Option" and then expand the "Propulsion Source" to reveal the propeller

- location. Modify the transverse coordinate back to 0.
3. For the “Propeller Model” parameter change from the Hough-Ordway Model to the Uniform Thrust Model. This will turn off any induced rotational flow.
 4. After you have changed to the Uniform Thrust Model you will see a new parameter called “Whole Propeller” which you should change to "No." In this case “No” implies that you are modeling half the propeller thrust which is correct for a symmetric simulation where the model is mirrored.

13.4 Reporting

After you have run simulations for one or more speeds for a given hull, Orca3D can create a report in Excel to tabulate and plot the results of the simulations as a formatted resistance/powering prediction including resistance/power, heave, and pitch. Excel must be available on your computer for this function to run.

Toolbar	<i>n/a</i>
Menu	Orca3D > Speed/Power > Create CFD Report
Command	OrcaCreateCfdReport

Upon running the command the following dialog will appear:

Create CFD Report

Project Name:

Project Description:

Report Type:

CFD Results Folder: ...

Check files to include in report:

- ☒ C:\Users\bhays\Documents\Simetrics\Data\Delft Catamaran\Baseline\10kt\Delft Catamaran 372_Rev2_9_4m beam mirrored_10kt_integrals.txt
- ☒ C:\Users\bhays\Documents\Simetrics\Data\Delft Catamaran\Baseline\15kt\Delft Catamaran 372_Rev2_9_4m beam mirrored_15kt_integrals.txt
- ☒ C:\Users\bhays\Documents\Simetrics\Data\Delft Catamaran\Baseline\20kt\Delft Catamaran 372_Rev2_9_4m beam mirrored_20kt_integrals.txt
- ☒ C:\Users\bhays\Documents\Simetrics\Data\Delft Catamaran\Baseline\25kt\Delft Catamaran 372_Rev2_9_4m beam mirrored_25kt_integrals.txt

Report Options

Number of Samples to Average:

Model-Ship Correlation

☒ None ☐ ITTC 1978 Ca ☐ ITTC Modified ☐ Custom Ca/deltaCf

Roughness Height: m

Create Report ... Cancel

Project Name and Description: Enter the relevant information for your project. This information may be changed once the report is created in Excel.

Report Type: Resistance Analysis Report or Powering Analysis Report. Select the type of report based on the type of simulations you have run. Note that if you select results files that are different than the Report Type, you will be given the option to deselect those results files. For example, if you select a Powering Analysis Report, but you select a resistance results files,

CFD Results Folder: Use the ... button to navigate to a folder beneath which are sub-folders containing the simulations that you have run (each speed or RPM will be in a folder beneath the folder that you enter here)

Check files to include in report: Each of the sub-folders with results will be shown, and by default they will be included in the report. If you wish to exclude any of the folders, uncheck them.

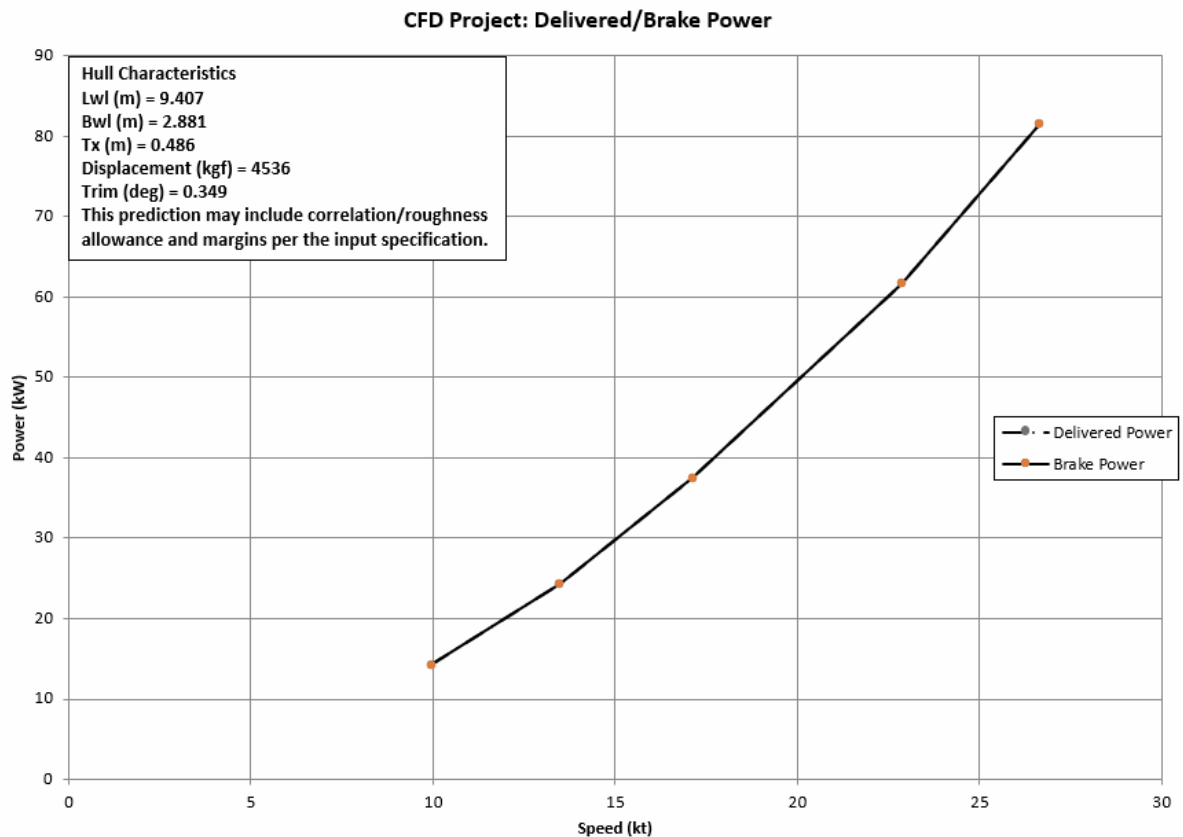
Number of Samples to Average: the tabulated value of the data channels are taken from the time history results (for example, heave vs. time). Since these values are not constant and are often periodic, even for a well-converged analysis, it is best to average some number of samples to get the reported value. By default, the last 10 samples are averaged to arrive at the reported value. This value may also be changed in the report after it is

created. Ideally the period of variation if it can be quantified and is consistent across channels. Viewing the time histories in the plots in Simerics will help you to estimate the period.

Model Ship Correlation: This allowance addresses unaccounted for differences between model and ship scales, and potentially for hull roughness depending on formulation that is chosen. Select a formulation, and if appropriate enter a Roughness Height. The Ca may also be changed in the report after it is created.

When you have entered all of the information, click on the Create Report button. Excel will open and display the report. The report has worksheets for the tabular data, plots of Resistance or Power, Heave, and Pitch, as well as one worksheet with the time history data for each speed or RPM. Definition of all of the report information is included below under **Report Nomenclature** and on the Definition worksheet of the spreadsheet.

	A	B	C	D	E	F	G	H
1	Project:	CFD Project						
2	Description:	CFD Project Description						
3	Date:	12/3/2018 9:01						
4								
5	Design Characteristics:					Unit Conversions:		
6	Lwl (m)	29.981	Displacement (kgf)	89738.565		Length	1	
7	Bwl (m)	9.370	LCG (m)	-15.833		Area	1	
8	Tx (m)	1.500	TCG (m)	0.000		Force	1	
9	Swet (m^2)	195.099	VCG (m)	0.000		Moment	0.101971621	
10	Sapp (m^2)	0.000	Sinkage (m)	1.500		PlaneAngle	57.29577951	
11	Sair (m^2)	0.000	Trim (deg)	0.000		MassDensity	1	
12	Caa	0.000	Heel (deg)	0.000		KinematicViscosity	1	
13	Capp	0.000	RhoW (kg/m^3)	1025.900		Speed	1.943844492	
14	Ca	0.00000	RhoA (kg/m^3)	1.225		Acceleration	1	
15	ks (m)	0.00000	NuW (m^2/s)	1.188E-06		Power	0.001	
16	Crough	0.00000	g (m/s^2)	9.806		Weight	0.101971621	
17	Cenv	0.000	Samples	100		Scale Ratio	1	
18	Margin	0.000						
19								
20	Speed (kt)	Speed StdDev (kt)	Fn	Rn	Heave (m)	Heave StdDev (m)	Pitch (deg)	Pitch StdDev
21	10.000	2.25562E-14	0.300	1.298E+08	-0.053	0.000501463	-0.102	0.0028
22	15.000	2.60264E-14	0.450	1.947E+08	-0.134	0.000118293	-1.332	0.0001
23	20.000	2.08211E-14	0.600	2.596E+08	-0.067	0.000218549	-1.853	0.0077
24	25.000	1.04105E-14	0.750	3.245E+08	-0.017	0.000243711	-1.639	0.000



Report nomenclature

Lwl Length on waterline in static equilibrium

Bwl Beam on waterline in static equilibrium

Tx Maximum draft in static equilibrium

Swet Wetted surface area in static equilibrium

Sapp Additional wetted surface area of appendages (beyond what was modeled in the simulation) in static equilibrium

Sair Additional aerodynamic surface area (beyond what was modeled in the simulation) in static equilibrium

Caa Still air drag coefficient for computing additional air drag beyond what was modeled in the simulation

Capp Appendage drag coefficient for computing additional appendage drag beyond what was modeled in the simulation

Ca	Model-ship correlation allowance addressing unaccounted for differences between model and ship scales and potentially for hull roughness depending on formulation chosen
ks	Hull roughness height
Croug h	Hull roughness drag coefficient (which can already be included in Ca depending on formulation chosen)
Cenv	Additional drag due to environment (waves and wind) specified as a fractional increase relative to the smooth water drag
Margin	Additional drag margin specified as a fractional increase relative to the sum of all other drag components
Displa cemen t	Vessel displacement for the specified static loading condition
LCG	Longitudinal center of gravity location (in the coordinate system of the Rhino model) for the specified static load condition
TCG	Transverse center of gravity location (in the coordinate system of the Rhino model) for the specified static load condition
VCG	Vertical center of gravity location (in the coordinate system of the Rhino model) for the specified static load condition
Sinka ge	Static equilibrium sinkage (this is different from the dynamic heave value reported from the simulation results)
Trim	Static equilibrium trim (this is different from the dynamic pitch value reported from the simulation results)
Heel	Static equilibrium heel
RhoW	Density of water in the simulation
RhoA	Density of air in the simulation
NuW	Kinematic viscosity of water in the simulation
g	Gravitational field constant in the simulation
Sampl es	Number of samples in the simulation results over which to average the reported time-varying values
Speed	Resultant simulation speed averaged over the specified number of samples.
Speed StdDe v	Standard deviation of the speed data channel measured over the specified number of samples. This provides a measure of variability of this data channel.
Fn	Froude number based on Lwl
Rn	Reynolds number based on Lwl

HeaveResultant dynamic heave over the specified number of samples. This is at the tow point for resistance runs (which defaults to the CG location) or at the CG for powered runs. This is in addition to the static heave associated with the static sinkage.

HeaveStandard deviation of the heave data channel measured over the specified number of StdDe samples. This provides a measure of variability of this data channel.

v

Pitch Resultant dynamic pitch angle averaged over the specified number of samples. This is in addition to any pitch angle associated with the static trim.

Pitch Standard deviation of the pitch data channel measured over the specified number of StdDe samples. This provides a measure of variability of this data channel.

v

Rcfd Resultant resistance from a "towed" CFD simulation averaged over the specified number of samples. This includes hydrodynamic and aerodynamic drag associated with all geometry modeled in the simulation.

Rcfd Standard deviation of the resistance data channel measured over the specified StdDe number of samples. This provides a measure of variability of this data channel.

v

Raa Additional still air drag associated with Sair

Rapp Additional appendage drag associated with Sapp

Ra Model-ship correlation drag associated with Ca

Rroug Hull roughness drag associated with Crough
h

Renv Environmental drag associated with Cenv

RmargMargin drag associated with Margin

Rtot Total drag including all drag components, both simulated and added

Ct Total drag coefficient determined from Rtot

Petot Total effective power determined from Rtot

NumP The total number of propulsors in the simulation (e.g. 2 for twin screw propulsion).
rops This is currently an input from the user.

RthrustResultant resistance from a powered CFD simulation averaged over the specified
t number of samples. This includes hydrodynamic and aerodynamic drag associated with all geometry modeled in the simulation along with any drag resulting from the propulsor-induced flow. The thrust deduction can be derived as R_{thrust} / R_{cfd} , where R_{cfd} is the resistance from a towed simulation.

RthrustStandard deviation of the resistance data channel measured over the specified
t number of samples. This provides a measure of variability of this data channel.

StdDe

v

Pthrust Power associated with Rthrust
t

J Propeller advance ratio defined as speed of advance, V_a , divided by the product of propeller rotational speed and propeller diameter.

J Standard deviation of the advance ratio data channel measured over the specified StdDev number of samples. This provides a measure of variability of this data channel.
v

EtaO Propeller open water efficiency as determined from the user-specified propeller performance data.

EtaO Standard deviation of the propeller open water efficiency data channel measured over StdDev the specified number of samples. This provides a measure of variability of this data channel.
v

Pdcfd Power delivered to the propeller from the simulation as determined from the user-specified propeller performance data. This value does not include the relative rotative efficiency of the propeller operating in the vessel flow field.

Pdcfd Standard deviation of the propeller delivered power data channel measured over the StdDev specified number of samples. This provides a measure of variability of this data channel.
v

Pdtot The total power delivered to all propellers as determined from the user-specified propeller performance data. This is $P_{dcfd} * NumProps$ and does not include the relative rotative efficiency of the propeller operating in the vessel flow field.

EtaR User-specified relative rotative efficiency accounting for the difference in propeller efficiency in open water compared to that when operating in the vessel flow field.

EtaM User-specified mechanical efficiency including all losses from the brake power generated at the engine to the power delivered to the propeller (e.g., gearbox losses, shaft bearing losses)

Pbtot Engine brake power determined as $P_{dtot} / (EtaR * EtaM)$

13.5 Creating Renderings

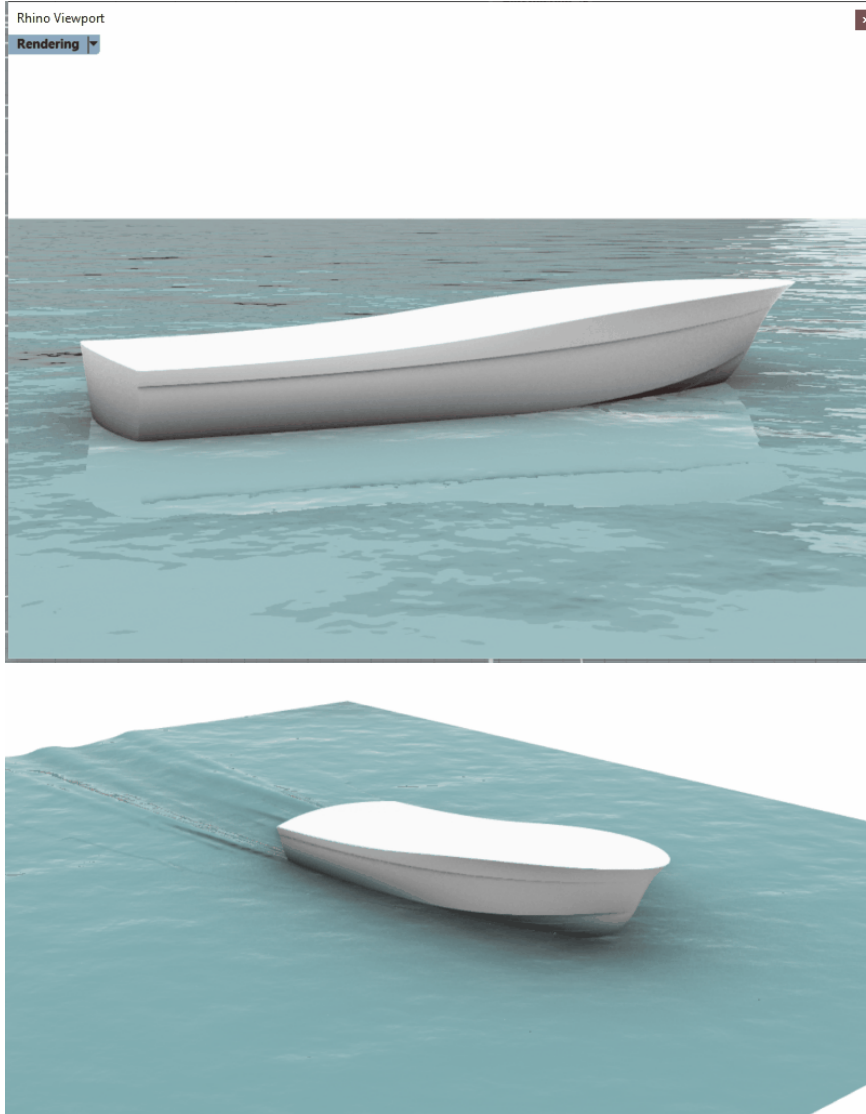
OrcaCreateCFDRender

Toolbar	<i>n/a</i>
Menu	Orca3D > Speed/Power > Orca3D Create CFD Render
Command	OrcaCreateCFDRender

This command generates a rendered viewport of the selected Rhino geometry together with the water surface. Two types of renders are supported. The first shows the model floating at static equilibrium (zero speed) based on the condition setup for the CFD simulation. The second shows the model in its dynamic heave and pitch attitude along with the water free

surface mesh extracted from the CFD simulation.

Here is a model rendered at zero speed, and then running, showing free surface that was computed in the CFD software.

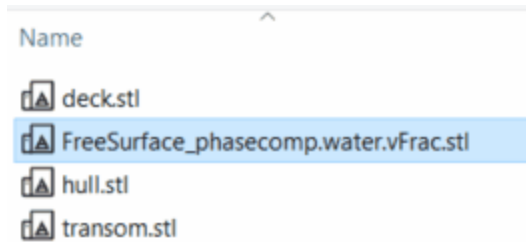


Running the command will first prompt you to select your surface(s). These do not need to be the same surfaces that were used in the CFD analysis. For example, while you may have only used the hull and a simple deck in the CFD analysis, these renderings might use a very detailed model with superstructure, etc.

Next, you are prompted to select a zero speed (Hydrostatic) render, or a CFD Simulation (running). Next, you are prompted to select the Simerics Project File (.spro) file that was used for the analysis. If you are creating a Hydrostatic rendering, a new window is created, showing the rendering. Note that a new Rhino layer is created with the transformed hull geometry and the water surface.

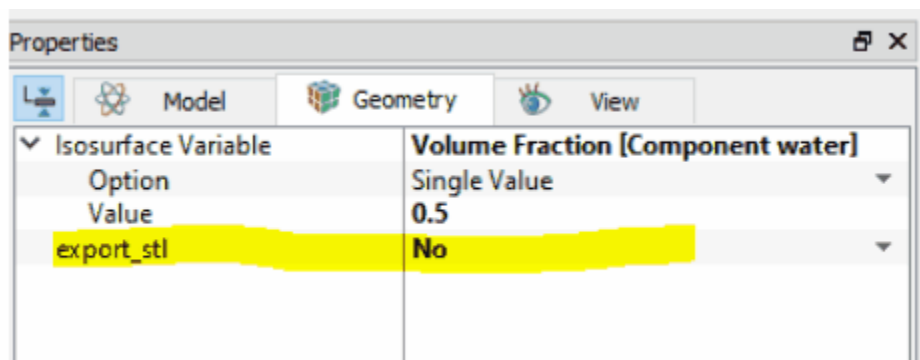
If you are creating a CFD Simulation, you are then prompted to select the file with the free

surface mesh from SimericsMP (note that this function is still a beta function in the SimericsMP software, so it does not exist in all versions; if you don't see the menu below in step 3, please contact us to get a beta version of SimericsMP with this function).



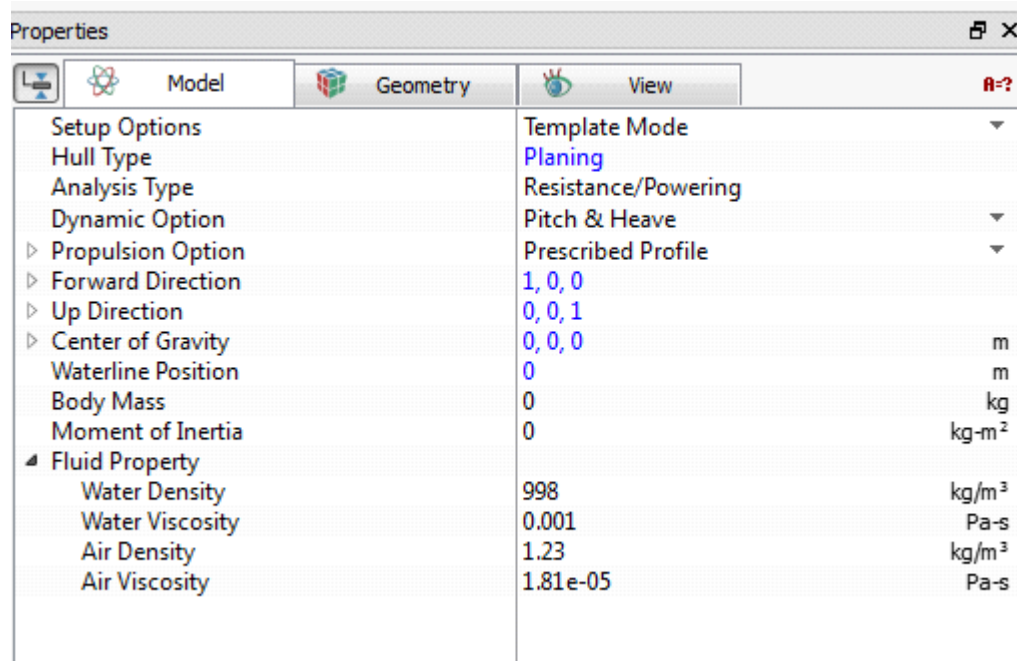
To create this file:

1. Open a simulation in SimericsMP and load the latest results file
2. In the Geometric entities window select the free surface
3. In the Geometry tab of the Properties panel you will see a new entry called "export_stl" as shown below. Click the dropdown that says No and click Yes. This action causes a file to be written to the Simerics simulation folder called "FreeSurface_phasecomp.water.vFrac.stl". This is the STL file representing the free surface mesh.



13.6 Working with Settings in SimericsMP

While many settings for the simulation are automatically set using input from Orca3D, you may also set and modify them directly in Simerics MP.



Hull Type: the type of hull. It is fixed from the marine mesher.

Analysis Type: the type of analysis.

Dynamic Option: choose the dynamics that will be applied into simulation.

Propulsion Option: choose the propulsion method. The details are described below.

Forward Direction: same definition as in marine mesher. Cannot be changed.

Up Direction: same definition as in marine mesher. Cannot be changed.

Center of Gravity: same definition as in marine mesher. Cannot be changed.

Waterline Position: same definition as in marine mesher. Cannot be changed.

Body Mass: the mass of the whole ship.

Moment of Inertia: the moment of inertia in pitch direction.

Fluid Property: the fluid and air properties input.

Propulsion options:

1. Prescribed Profile:

Dynamic Options	Pitch & Heave
▾ Propulsion Option	Prescribed Profile
Target Velocity	10 m/s
Ramp Up Time	2 s
▸ Forward Direction	1, 0, 0

Target Velocity: the target ship velocity

Ramp Up Time: the linear ramp up time

2. Velocity Profile:

Dynamic Options	Pitch & Heave
▾ Propulsion Option	Velocity Profile
Velocity Profile	0 m/s
▸ Forward Direction	1 0 0

Velocity Profile: the expression for velocity profile.

3. Propulsion Source: Force Vector

Dynamic Options	Pitch & Heave
▾ Propulsion Option	Propulsion Source
▾ Propulsion Source	Force Vector
Propulsion ID	0
▸ Position	0, 0, 0 m
▸ Direction	-1, 0, 0
Force Expression	0 N
Propulsion Source	No

Propulsion ID: the unique ID of the propulsion source.

Position: the absolute position of the point where force vector is applied.

Direction: the relative propulsion direction vector.

Force Expression: the expression of force profile. **Note: For symmetric runs, the force will be mirrored across the centerplane. If the force is on the centerplane, 1/2 of the total force should be entered.**

4. Propulsion Source:

Dynamic Options	Pitch & Heave
▾ Propulsion Option	Propulsion Source ▾
▾ Propulsion Source	Propeller Model ▾
Propulsion ID	0
▷ Position	0, 0, 0 m
▷ Direction	-1, 0, 0
Propeller Model	Hough-Ordway Model ▾
Propeller Diameter	0 m
Hub Diameter	0 m
Hub Thickness	0 m
Propeller Direction	Right-handed ▾
Propeller RPM	0 rpm
Kt Curve	0
Kq Curve	0
Propulsion Source	No ▾
▷ Forward Direction	1 0 0

Propulsion ID: the unique ID of the propulsion source.

Position: the absolute position of the point where force vector is applied.

Direction: the relative propulsion direction vector.

Propeller Model: the propeller model, Hough-Ordway Model and Uniform Distribution Model

Propeller Diameter: the diameter of whole propeller.

Hub Diameter: the diameter of propeller hub.

Hub Thickness: the thickness of the propeller hub.

Propeller Direction: the direction of propeller. Looking from stern, the right-handed propeller rotates clockwise.

Propeller RPM: the rotation speed of propeller.

Kt Curve: the open water propeller Kt vs. J curve.

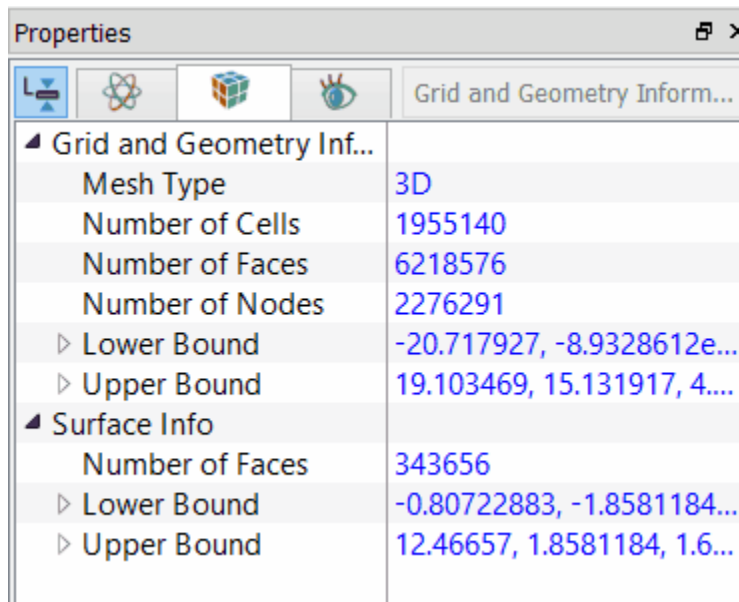
Kq Curve: the open water propeller Kq vs. J curve.

13.7 Changing the Mesh in SimericsMP


The mesh is created automatically when the .spro file is loaded, using default settings. If you are not satisfied with the mesh or wish to explore the effects on the results of varying mesh settings, you can control a number of parameters in the Simerics MP interface.

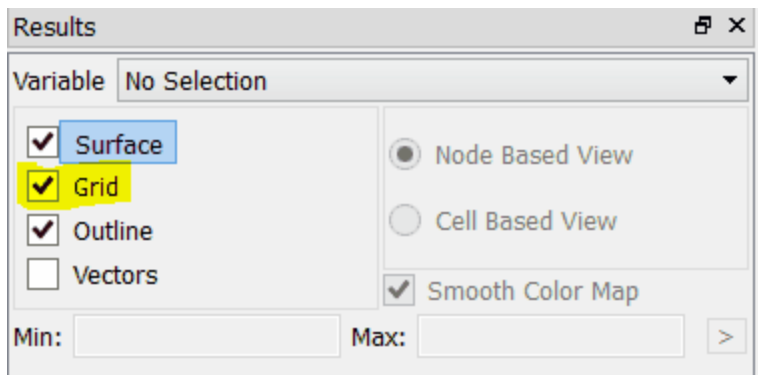
Viewing the Mesh

To see information about your current mesh, select "Grid and Geometry Information" in the Mesh tab of the main panel. In the Properties panel, select the Geometry tab.

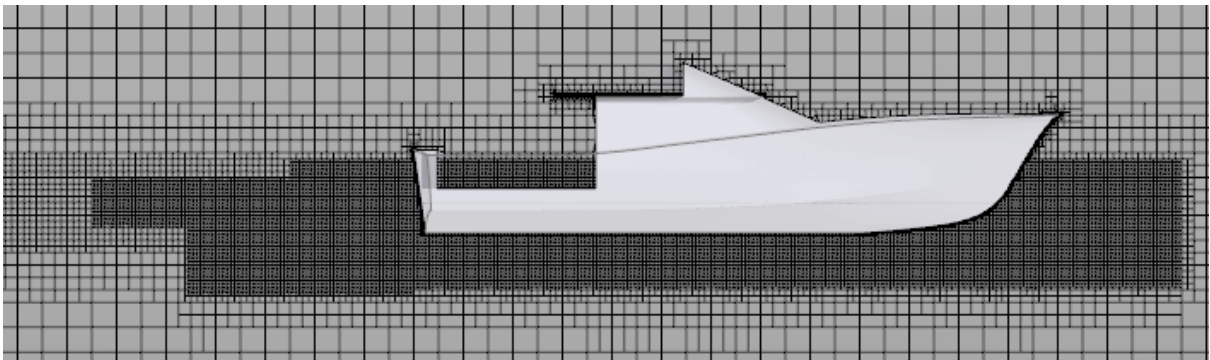


To view the mesh, select the marine_symmetry from the list of Boundaries in the Geometric

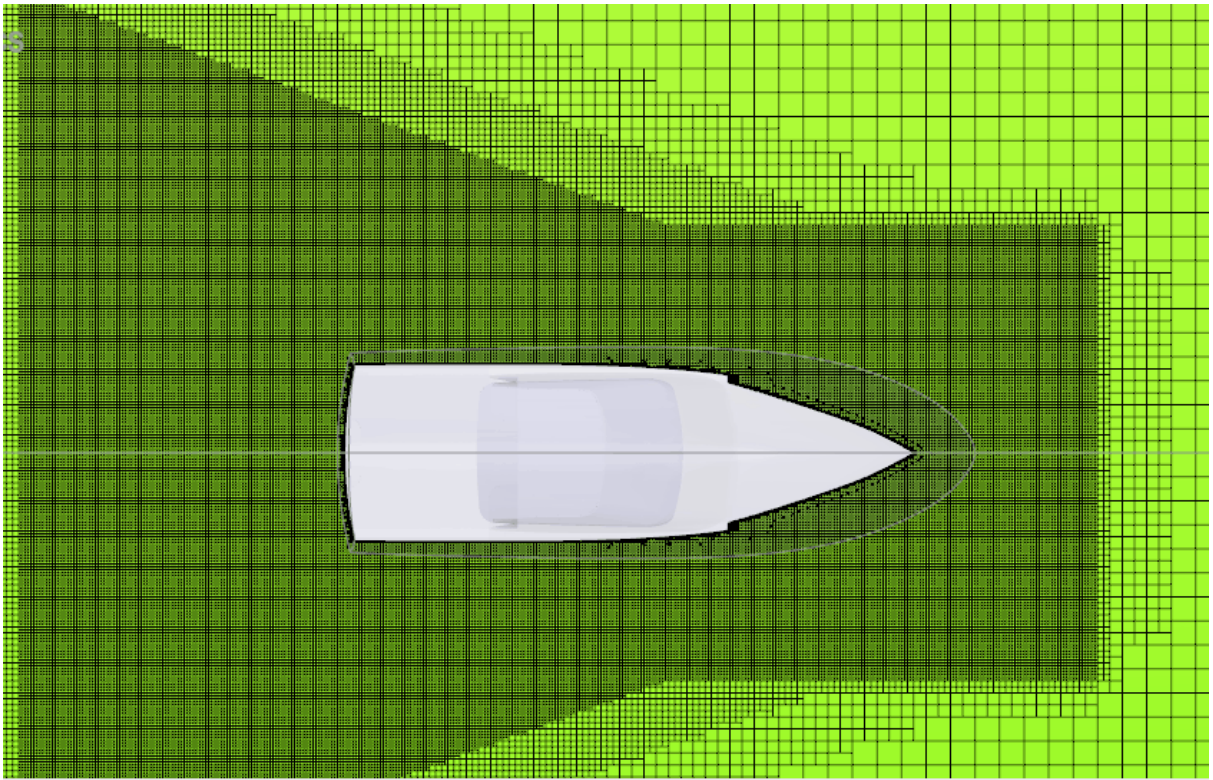
Entities panel. Next, switch to a profile view by clicking on the view icon () , and selecting Bottom View (-Y). Finally, in the Results panel, check the Grid box:



You will see a view showing how the mesh is refined:

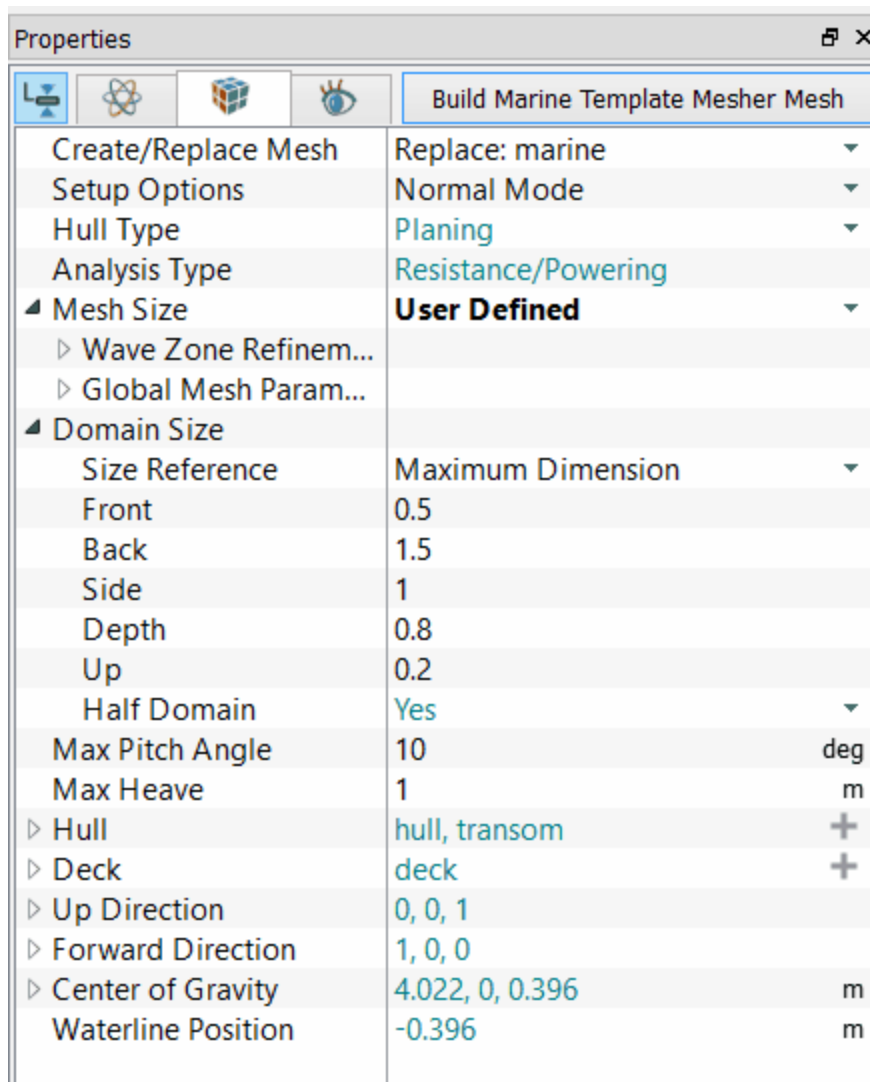


To see a planview, click the view icon and select Front View (+Z). Then in the Geometric Entities panel, select the Free Surface. Finally, in the Results panel, check the Grid box:



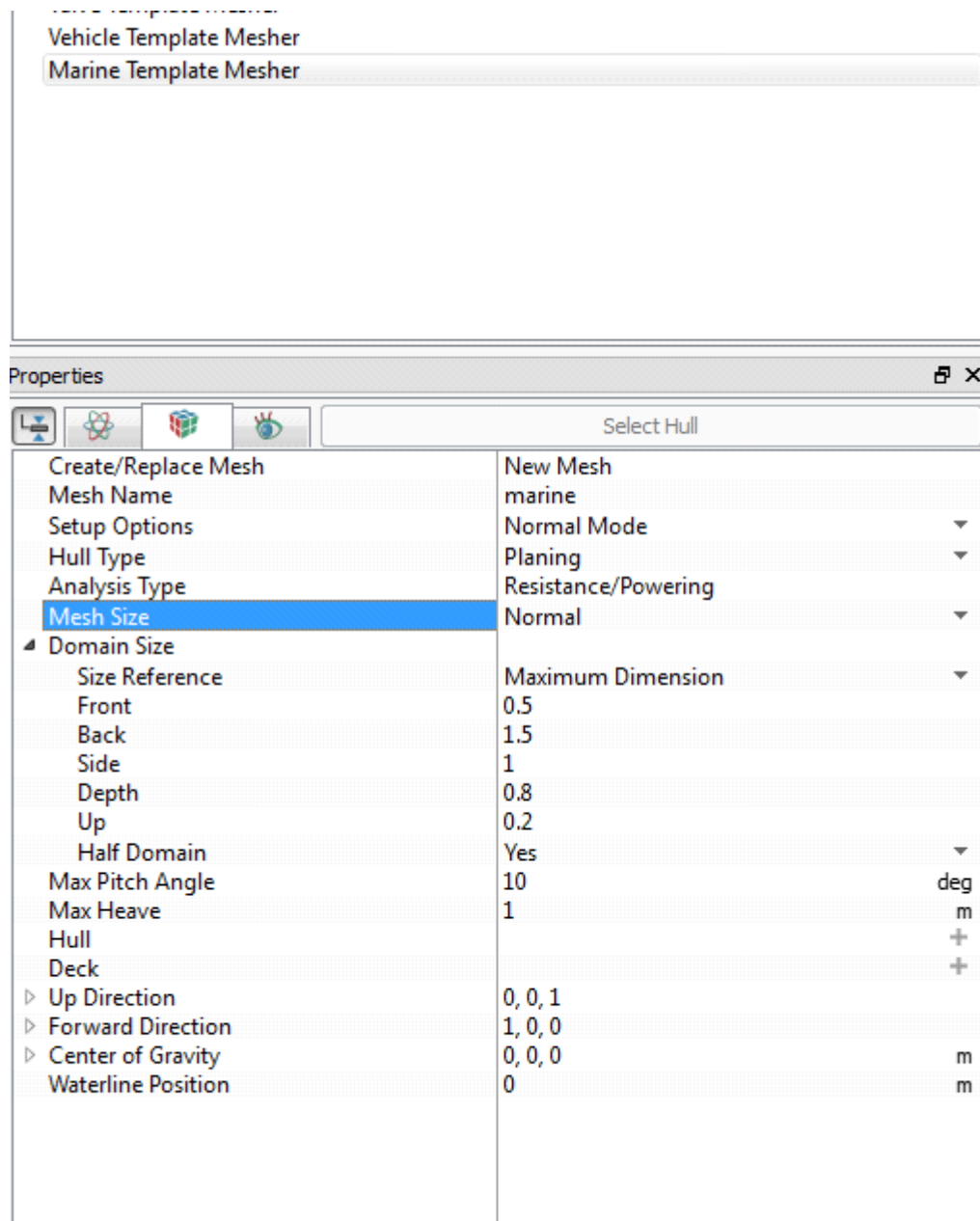
Changing the Mesh

To change the mesh, select "Built Meshes" in the Geometric Entities panel. Then, in the Properties panel, select the Geometry tab.



You should see the "Build Marine Template Mesher Mesh" button at the top, and you should select "Replace:marine" next to Create/Replace Mesh. Then modify the desired parameters, and click on "Build Marine Template Mesher Mesh." Be sure to save your .spro file when the new mesh has been created. Note that you will need approximately 1 GB of RAM per 1 million cells in the mesh (in addition to what is required for the operating system).

The available parameters are described below:



Mesh Name: The name for the computational domain.

Hull Type: The type of analyzed ship hull. It has options of planing and displacement.

Analysis Type: The corresponding analysis will be done.

Mesh Size: Define the mesh size of computational domain. It has multiple options of Coarse, Normal, Fine and User Defined. Note that the settings that are shown for "Normal" won't necessarily result in

the same mesh that you get by default when bringing in the geometry from Orca3D, because when geometry is read from Orca3D additional logic is applied (e.g., checking for a very high length to beam ratio) and the mesh is modified as a result.

More options are available for the User Defined mesh.

Domain Size: Define the computational domain size. By default, the parameters are non-dimensionalized by the maximum dimension (usually the length of the vessel). Alternatively, you can select that they be non-dimensionalized by "Each dimension" (Front and Back by vessel length, side by vessel beam, and Depth and Up by vessel depth), or you can enter the Absolute Coordinate for each parameter.

Size Reference: the reference options to define the size.

Maximum Dimension: The domain sizes are all relative to the maximum dimension of the CAD surface. This is usually the length of the vessel.

Each Dimension: The domain sizes are relative to the dimension of CAD surface at each direction (Front and Back by vessel length, side by vessel beam, and Depth and Up by vessel depth).

Absolute Coordinate: The domain is sized by entering dimensions in meters.

Max Pitch Angle: The maximum pitch angle allowed.

Max Heave: The maximum heave allowed.

Hull: Selection of CAD surface(s) representing hull.

Deck: Selection of CAD surface(s) representing upper structure (out of water).

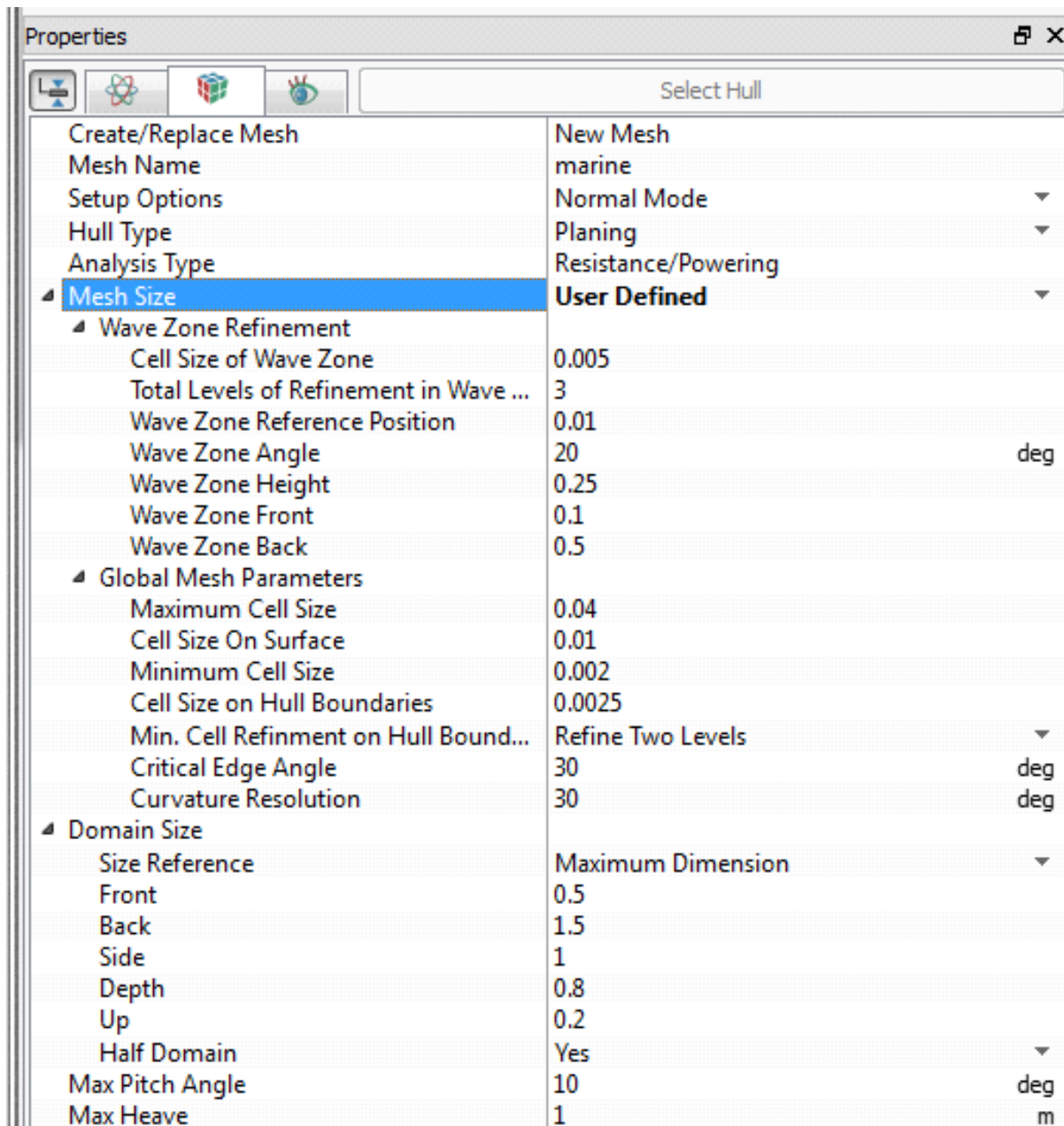
Up Direction: The definition of up direction.

Forward Direction: The definition of forward direction.

Center of Gravity: The absolute position of center of gravity.

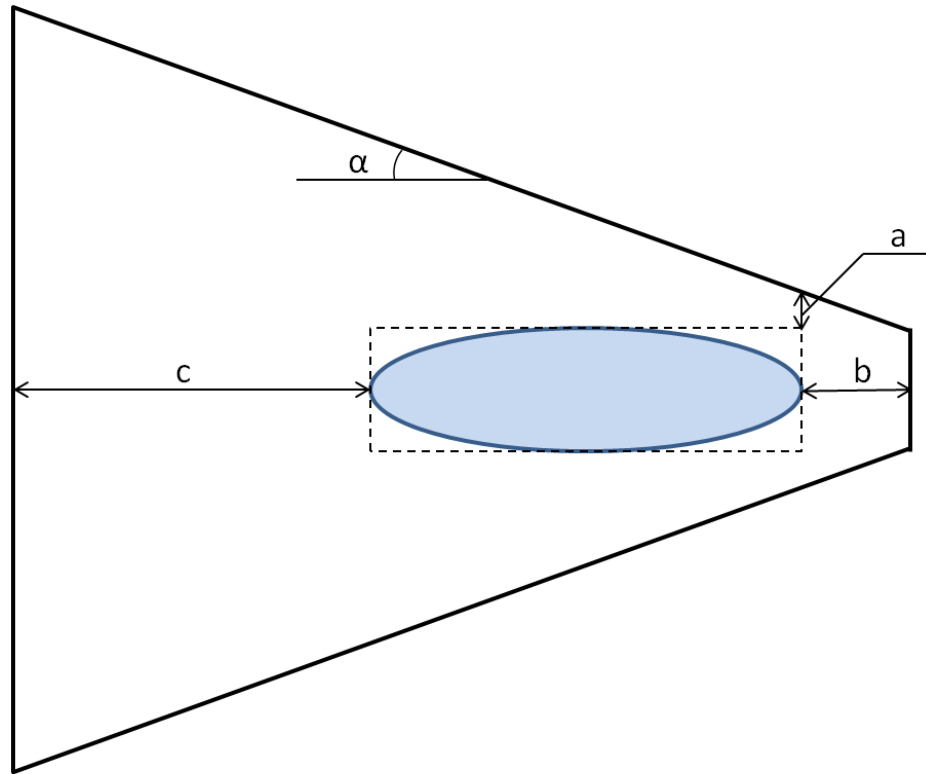
Waterline Position: The waterline position. It is defined relative to center of gravity and is perpendicular to up direction.

Advanced Mesh option: Select "User Defined" next to Mesh Size



Wave zone is the predefined refinement zone which covers the induced wave in marine CFD

simulation.



Wave Zone Refinement Parameters:

Cell Size of Wave Zone: the minimum domain cell size of wave zone. Cell size is non-dimensionalized by vessel length.

Total Levels of Refinements in Wave Zone: the total number of levels of refinement to transient from minimum domain cell size to maximum domain cell size.

Wave Zone Reference Position: the width at ship front, a . The length is relative to ship max dimension.

Wave Zone Angle: the angle of wave zone, α , should be bigger than Kelvin angle.

Wave Zone Height: the height of wave zone, relative to ship height.

Wave Zone Front: the forward end of wave zone, b , relative to ship length.

Wave Zone Back: the aft end of wave zone, c , relative to ship length.

Global Mesh Parameters:

These are defined below and have the same definitions as those in general mesher. Further explanation can be found in the Simerics MP Help files under Mesh Panel.

Maximum Cell Size: This global parameter is applied to all volumes/boundaries. In most cases, the Maximum Cell Size applies to the fluid domain outside any refinement zones (Wave, Hull, User-defined, etc.), while the Minimum Cell Size will be a limit applied to a solid boundary (Hull, Deck, Transom). Cell size is non-dimensionalized by vessel length.

Cell Size on Surface: The target cell size on any solid surface, assuming other meshing criteria (critical edge angle, curvature, etc.) have been satisfied. Usually interpreted as a “maximum” value. Cell size is non-dimensionalized by vessel length.

Minimum Cell Size: See Maximum Cell Size description

Cell Size on Hull Boundaries: See Cell Size on Surface; this is a similar parameter, but it overrides the Cell Size on Surface for the Hull and Transom boundaries. Cell size is non-dimensionalized by vessel length.

Min. Cell Refinement on Hull Boundaries: This parameter is an integer from 1-3, indicating how to transition from “hull” to “wave” zone near the solid surface. For example, a value of 2 means that there are two levels of intermediate-sized cells between the Hull boundary and the Wave Refinement Zone.

Critical Edge Angle: Critical Edge Angle is a parameter used to control the accuracy with which the Mesher resolves edges in CAD Surfaces. Smaller edge angles will provide higher resolution.

Curvature Resolution: Curvature Resolution is a parameter used to control the accuracy with which the Mesher resolves curves in CAD Surfaces. Smaller values result in higher resolution meshes.

13.8 Using the Expression Editor

In some simulations, it is useful to supply an expression instead of a fixed value. For example, you may wish to provide a velocity profile as a function of time, or in a powered run you may wish to supply the RPM as a function of time. This is done with the Expression Editor.

The Simerics Help file has a detailed section on the Expression Editor. Note that in addition to an expression, you can supply a table of values, which at times is more useful.

Available variables in the marine module include:

```
marine.forward_vel
marine.pitch
marine.heave
marine.resistance
marine.prop_T1 (thrust of propeller 1)
marine.prop_torque1 (torque of propeller 1)
marine.prop_power1 (power of propeller 1)
marine.prop_J1 (advance coefficient of propeller 1)
```

In addition, we define a few variables in powered runs which may be used:

```
prpm1 (rpm of propeller 1)
kt1 (thrust coefficient of propeller 1)
kq1 (torque coefficient of propeller 1)
```

In the following example, we have a 3 second linear ramp on RPM, going from 0 to 3000. Also, the kt1 and kq1 values are found from a table in the text files kt1.txt and kq1.txt:

```
prpm1 = time < 3 ? time * 1000 : 3000
kt1 = table(kt1.txt, marine.prop_J1)
kq1 = table(kq1.txt, marine.prop_J1)
```

(Note that this particular example is automatically created in Orca3D when you specify a linear RPM ramp in the Propulsor Performance dialog.)

Using a Table and Expression to Model Velocity vs. Time for a Resistance Run

If you wanted to do a velocity profile for a Resistance run, it would probably be easiest to do it with a table. For example, you could have a text file called velocity.txt which looks like:

```
<?xml version="1.0" encoding="ISO-8859-1"?>
<table size="7" outside="extrapolation">
# Time   Vel
0 0
5 5.0
10 5.0
15 7.5
20 7.5
25 10
30 10
</table>
```

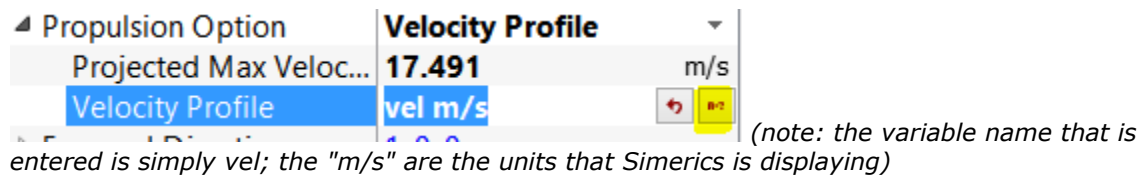
This would accelerate the boat linearly from 0 to 5 m/s in the first 5 seconds, stay at 5 m/s for

another 5 seconds, then accelerate it to 7.5 m/s over the next 5 seconds, stay at 7.5 m/s for another 5 seconds, and so on. If you want to accelerate between speeds in something other than a linear fashion, you can add more intermediate values.

Open the expression editor by clicking on the "A=?" icon (, and then enter the following expression in the Global Expressions:

```
vel = table(velocity.txt, time)
```

Then select the Marine module, and in the Properties panel select Model. Under Propulsion Option, select Velocity Profile. Under Velocity Profile, you would enter a variable name, say "vel." Be sure to enter the Projected Max Velocity value, matching the highest velocity in your velocity.txt file. This will ensure that your time step is suitable for all of the speeds.

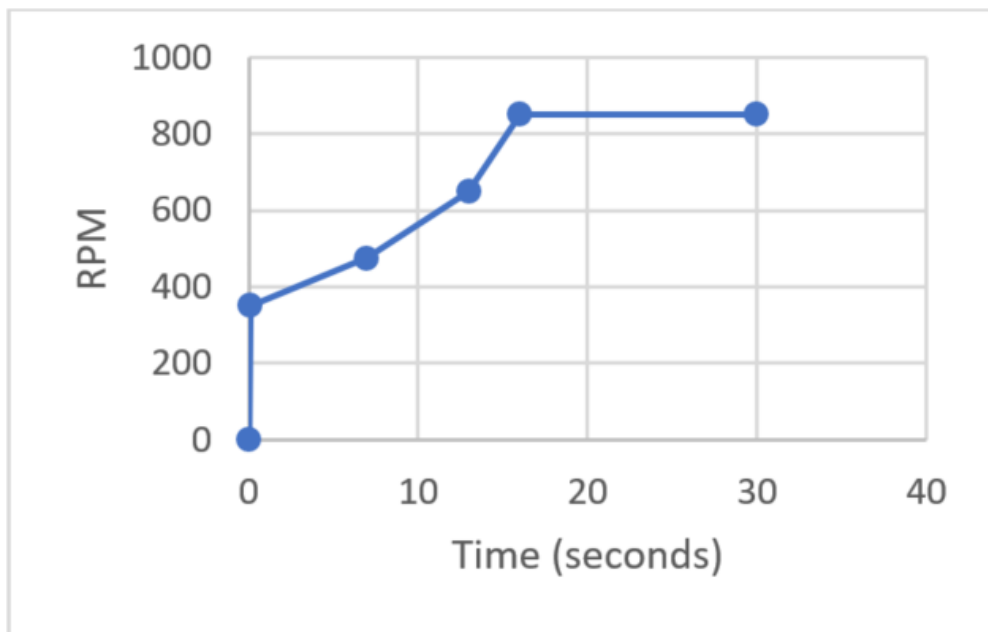


Using a Table and Expression to model an RPM vs. Time curve

When doing a powered run, you have the option of entering a fixed RPM (where the propeller starts at that value and remains there for the entire run), or you may enter a time ramp. In this case, the RPM varies linearly from 0 to the RPM value that you have entered, over the number of seconds that you enter.

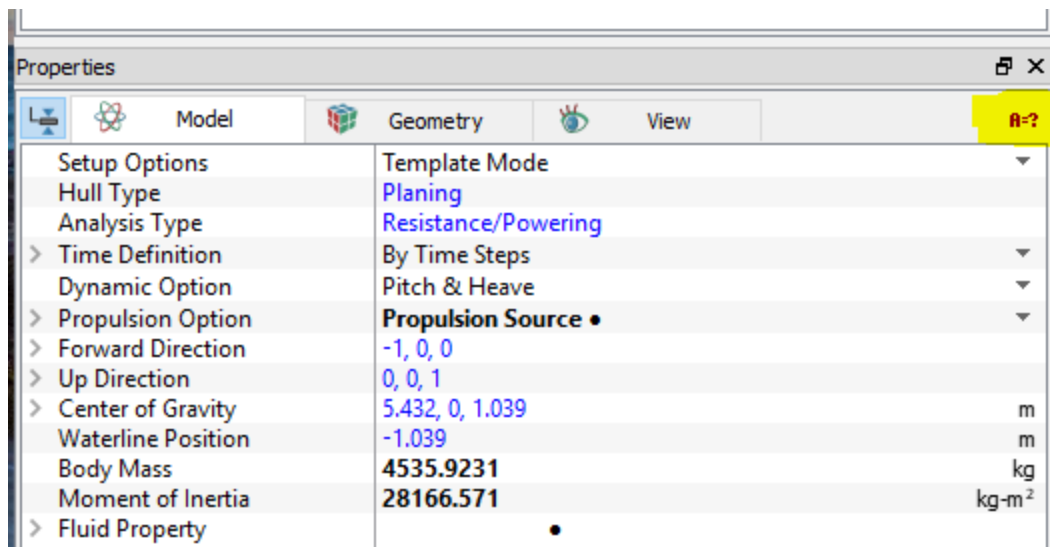
If you want to vary the RPM in a more precise way, you can create a table of RPM vs. time. In this example, we'll assume that we have the following information from some previous full-scale tests:

Time	RPM
0	0
0.1	350
7	475
13	650
16	850
30	850



Note that the final value for time (30 in this example) should be higher than the length of time you expect to analyze. There is no reason not to set it to something much higher, e.g., 100.

We will use the expression editor capability in Simerics to model this behavior. First, in the Orca3D CFD interface, just put any value in the RPM field (e.g., 1000), and then generate the Simerics simulation file as normal (at the bottom of the dialog, check the box that says “Prepare files but don’t start simulation,” and then click Create Files). Now open Simerics and open your .spro file. Go to the Model window and select the Marine module. Then in the Properties window you will see an icon to open the Expression Editor as shown highlighted below. Click on that icon.



Once you open the Expression Editor you will see an editing window. One of the lines

(probably the second) will say something like `prpm1 = 1000` (or whatever RPM you set in Orca3D). Change that line to read,

```
prpm1 = table(rpm.txt,time)
```

This expression means set the RPM for propeller 1 to be the value in the lookup table called "rpm.txt" using a lookup value of time.

The last step is to create the table. Use a text editor to create a file called "rpm.txt" that must be located in the same folder where all the other Simerics files are located (this is the path you specified in Orca3D with a subfolder name corresponding to the rpm you entered). The data in the RPM text file should be of the following form. You may have fewer or more lines of data, but it is important that the value for "table size" is the number of values in the table. Save this file, and then start the simulation.

```
<?xmlversion="1.0" encoding="ISO-8859-1"?>
<table size="6"outside="extrapolation">
# Time(sec)   RPM
0 0
0.1 350
7 475
13 650
16 850
30 850
</table>
```

13.9 Running Multiple Speeds

Using a Python script to automate the analysis of multiple speeds or RPMs

If you want to automate the process of running multiple speeds, there are two options; using a Velocity Profile [as described here](#)^[446], or a Python script as described below. The Velocity Profile does everything in one run, accelerating from one speed to the next. This has the potential to save some time, although you have to have a good estimate of how much time will be required to reach convergence before moving on to the next speed. Also, since all of the results are in a single run, the Orca3D CFD Report function will not work; it will only report the last speed in the run.

Below you will find a Python script that is used to run multiple speeds or RPMs in succession automatically. Here are the steps to follow:

1. In order to run a Python script you must first make sure you have Python installed. It is free and can be downloaded from here, <https://www.python.org/downloads/> (this script has been tested with version 3.7.1). During installation, be sure to check the box that adds Python to your path.
2. After installing Python, you may find that one component, win32api, was not installed by

default and must be installed separately. To do so, open a Windows command prompt and type “python –m pip install pypiwin32” without the double quotes (if you don't know how to open a command prompt in your version of Windows, search "how to open a command prompt in Windows").

3. If you check the "Create Python Run Script" in the Simerics CFD Options dialog in Orca3D, a Python script similar to the one shown below will be created (See [Getting Started in Orca3D](#)^[372]). Otherwise, you can copy and edit the example below, and then you need to make a few changes in the script for your specific setup. If you open the .py file in a text editor there are several comments labeled “Step 1, Step 2” ... These should be self-explanatory. When specifying the path to the folder, notice that there are two backslashes \\. Once you have finished editing the script, it's easiest if you save the script in your user folder, because this is the folder you will be in when you open a Windows command prompt (e.g., c:\Users\yourname).
4. Now you should be ready to go. Open a command prompt and type “python marineSeqRun.py” without the double quotes (if you created the script in Orca3D, the name will be different, based on your Project Name and it will be in the Project Path; you can just double-click the .py file). It should start the first run. When running Simerics from Python it will not open a user interface, so the only clues you have that it is doing something is (a) the command line has not returned back to the prompt and (b) you can look at the Simerics output files (e.g., ...integrals.txt) and see that the information in them is growing. You can stop the process by closing the command prompt by clicking on the red X. You will get feedback at the command line when a simulation has finished and the next one is starting. The run is considered finished when the convergence criteria (defined in the python script) have been met, or the Number of Time Steps have been completed.
5. Note that this will run each .spro file in sequence using the default values for Number of Time Steps, Results Saving Frequency, etc. (remember that by default, Results are saved only at the end of a run). ***Before running the script, you should open each .spro file in Simerics, change any settings and save the file. This will save your changes as well as the .sgrd file (which contains the mesh). In particular, if you want to produce an animation, you will need to adjust the Results Savings Frequency. Each time the results are saved you will have one frame in your animation (frames = Number of Time Steps / Results Saving Frequency). It's also a good idea to increase the Number of Time Steps, to be sure that the analysis converges before running out of Time Steps.***

You can copy and paste the script below into a text editor (e.g., Notepad++):

```
# -*- coding: utf-8 -*-
"""
```

```
Created on Tue May 23 17:29:49 2017
```

```
@author: cjw
"""
```

```

import os, subprocess
import time
import signal
import win32api
import win32con

# Step 1: Make sure the path to the SimericsMP executable is correct
executable = os.path.normpath("C:\\Program Files\\Simerics\\SimericsMP.exe")

# Step 2: Set the path to the folder containing the simulation subfolders (e.g. speeds or rpm
subfolders)
pro_path = os.path.normpath("C:\\Users\\yourname\\Documents\\Simerics\\Data\\myboat")

# Step 3: Set the base name of the file to run (e.g. the .spro file without the spro extension)
base_name = "Myboat"

# Step 4: Define the names of the subfolders (typically the speeds or rpms) to run
suffix = ["27kt", "29kt", "31kt"]

# Step 5: These control what fields are examined to determine convergence. The defaults
should be ok in general.
var_id = [1, 3, 4] # entry position in _integrals file
res_tol = [100, 0.1, 0.1] # the corresponding tolerance

for s in suffix:
    pro_name = base_name + "_" + s
    project = pro_path + "\\ " + s + "\\ " + pro_name + ".spro"
    integral_res = pro_path + "\\ " + pro_name + "_integrals.txt"

    #check if old integral result exist
    if os.path.exists(integral_res):
        num = 1
        while True:
            newname = integral_res[:-4] + str(num) + integral_res[-4:]
            if os.path.exists(newname):
                num += 1
            else:
                os.rename(integral_res, newname)
                break

    #check if project file exist
    if os.path.exists(project):
        cmd = "\"" + executable + "\" -run \"" + project + "\""
        print(cmd)
        proc = subprocess.Popen(cmd)

        while True:
            if proc.poll() is not None:

```

```

        print ("The project " + project + " is finished!")
        break
    if os.path.exists(integral_res):
        print ("let's check")
        with open(integral_res,"r") as resfile:
            lines = resfile.readlines()
            if len(lines) > 3:
                line0 = lines[0]
                line1 = lines[-2]
                line2 = lines[-1]
                res0 = line0.split()
                res1 = line1.split()
                res2 = line2.split()
                #print (res1[1])
                #print (res2[1])

                #check the convergence
                conv_num = 0
                ii = 0
                for id in var_id:
                    name = res0[id]
                    diff = abs(float(res1[id])-float(res2[id]))
                    tol = float(res_tol[ii])
                    print ("name: " + name + " diff: " + str(diff)

+ " tol: " + str(tol))

                    if (diff < tol):
                        conv_num += 1
                        ii += 1
                if (conv_num == len(var_id)):
                    print ("The project "+pro_name+" is
converged.")

                    # kill the process with ctrl+c, this will
save the last res files.

                    if proc.poll() is None:
                        try:
                            win32api.
GenerateConsoleCtrlEvent(win32con.CTRL_C_EVENT, 0)
                                proc.wait()
                                except KeyboardInterrupt:
                                    pass
                                break
                        time.sleep(30)

    else:
        print("The project "+pro_name+" is not exist.")

```


13.10 Specialized Analyses

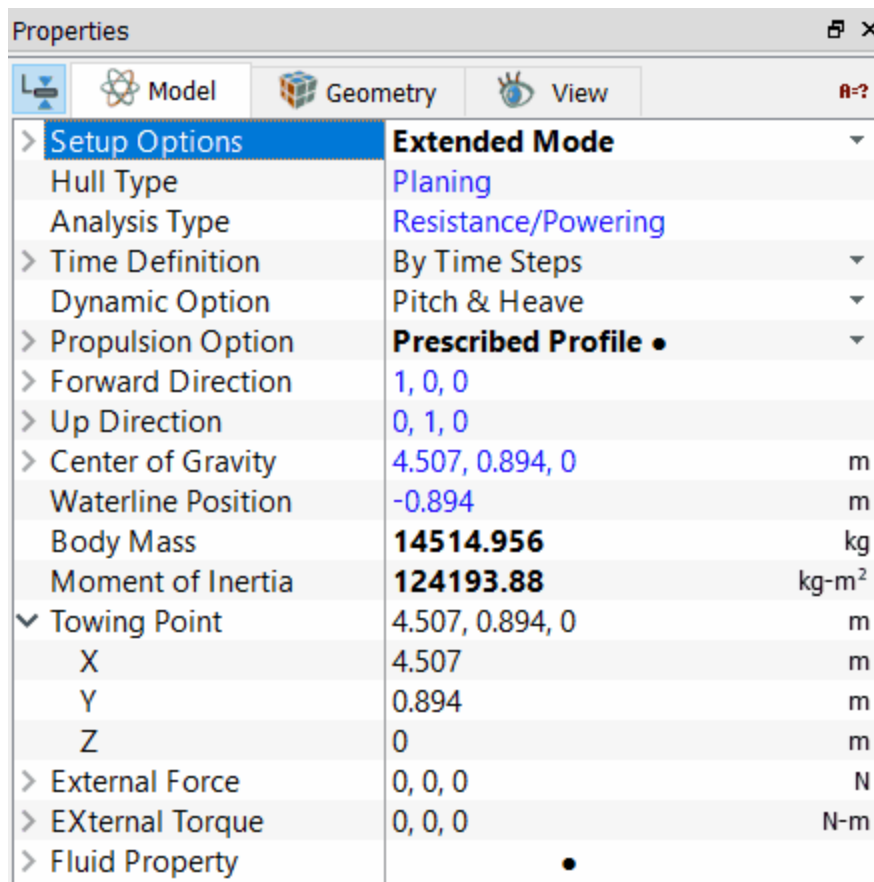
This section describes approaches to running analyses that are outside of the usual resistance or powered runs.

13.10.1 A Vessel Being Towed

A Vessel Being Towed

If you want to analyze the performance of a vessel being towed (e.g., a tender behind another boat), you can change the towing point in a resistance analysis. By default, the towing point is at the center of gravity, but you can locate it at the actual location of the tow line.

1. Select the Marine module in the Model tab of the Main pane.
2. In the Properties pane, select the Model tab.
3. In Setup Options, change from Template Mode to Extended Mode.



4. You will now see Towing Point. Enter the X, Y, Z values for the point
6. Remember that these values correspond to the coordinate system after Orca3D has transformed the boat into its equilibrium flotation condition). If you want to check that the

location is correct, you can put in a Monitoring Point. In the Geometric Entities tab, click on the "Add a Monitoring Point" icon. Select the point in the table. In the Properties pane, select the Geometry tab, and enter the X, Y, Z values for your towing point. This will give you visual confirmation that you have it in the correct location by showing the Monitoring Point at your towing point.

13.10.2 Bollard Pull Analysis

Bollard Pull Analysis

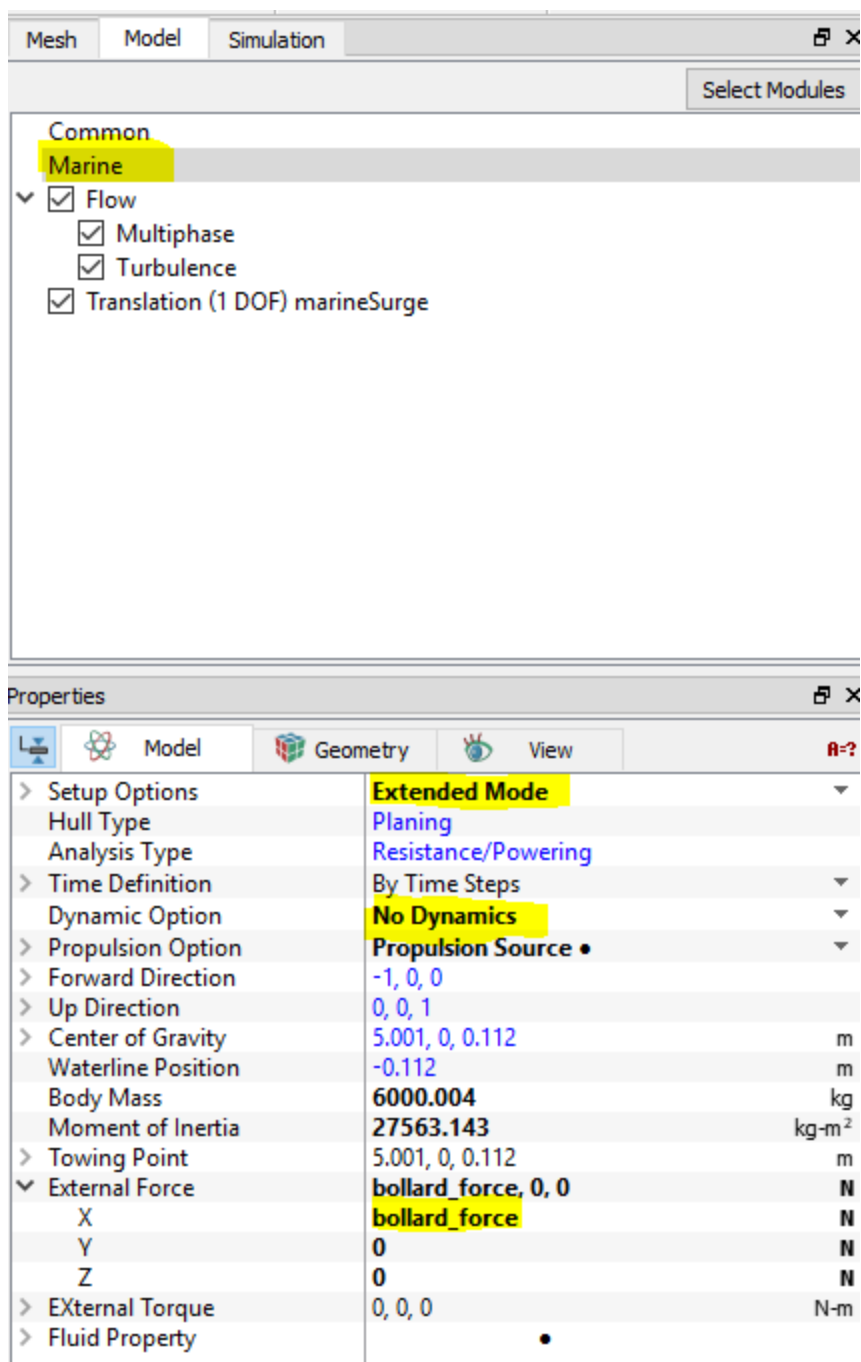
Once you have created the Simerics run files in Orca3D, follow this procedure to do a Bollard Pull Analysis.

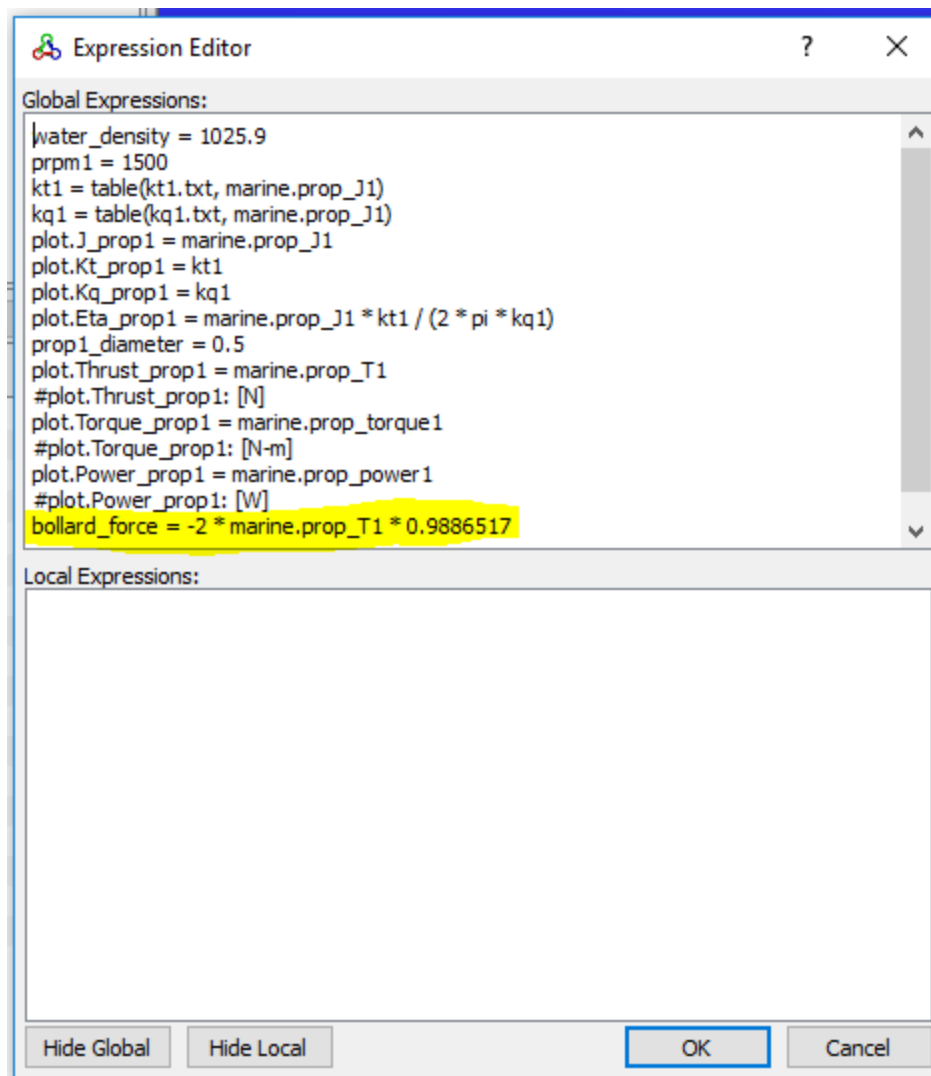
1. Select the Marine module and change the Setup Option to "Extended Mode."
2. Turn off heave and pitch dynamics because the external force is at the CG and will result in a moment with the thrust force which we don't want.
3. Expand External Force and place the cursor in the X field. Click the little icon at the right in the field that says "A=?" to open the expression editor. In the expression editor enter the equation for "bollard_force". This is shown below:

`bollard_force = -2 * marine.prop_T1 * 0.9886517;`

The -2 in this example is to account for the second propeller (twin screw) and the 0.988 was to account for the shaft angle.

4. Close the expression editor and in the External Force X field enter "bollard_force".





13.10.3 Propeller Wake Survey

Simulating a Propeller Wake Survey

Detailed propeller design often relies on a description of the inflow wake distribution in the plane of the propeller in order to properly design the blade shapes to maximize efficiency, minimize cavitation, and reduce the effects of the unsteady propeller forces (like noise and vibrations). For many years scale model testing has been used to predict the wake distribution by running tests either in a towing tank or a flow channel over a range of vessel speeds and using a measurement device (such as pitot tubes or Laser Doppler Velocimetry) to measure the local flow velocities in the plane of the propeller. It is possible to use Orca3D Marine CFD to simulate and measure the wake distribution. This approach has the benefit of not being limited to Reynolds numbers associated with smaller scale models since the CFD simulations can be run at full scale. The simulation setup can be performed using either a fully manual approach or a semi-automated approach as described below.

Manual Approach

To simulate a propeller wake survey with Orca3D Marine CFD using the manual approach, the following steps should be performed:

1. First generate one or more CFD resistance simulations at the speeds of interest in the way you normally would with Orca3D Marine CFD. Wake measurements are traditionally made in resistance simulations with appendages but in the absence of the propeller.
2. The wake survey process relies on distributing a series of "monitoring points" in SimericsMP over the plane of the propeller. As the name implies monitoring points allow the user to monitor the local flow behavior, including flow velocities, at specific locations. Because the determination of monitoring point locations is more easily accomplished in a CAD tool like Rhino, we start by opening the Rhino model containing the geometry used to generate the CFD simulation. Start by first transforming the Rhino model so that the $z = 0$ plane is the static flotation plane. This is done to match the geometry transformation that is applied in the CFD simulation. To do this, run the OrcaHydrostatics command, enter the mass properties or flotation plane at which the simulations are being performed and check the box that says "Transform Model to Resultant Condition" as shown below.

Orca3D Hydrostatics & Stability Analysis

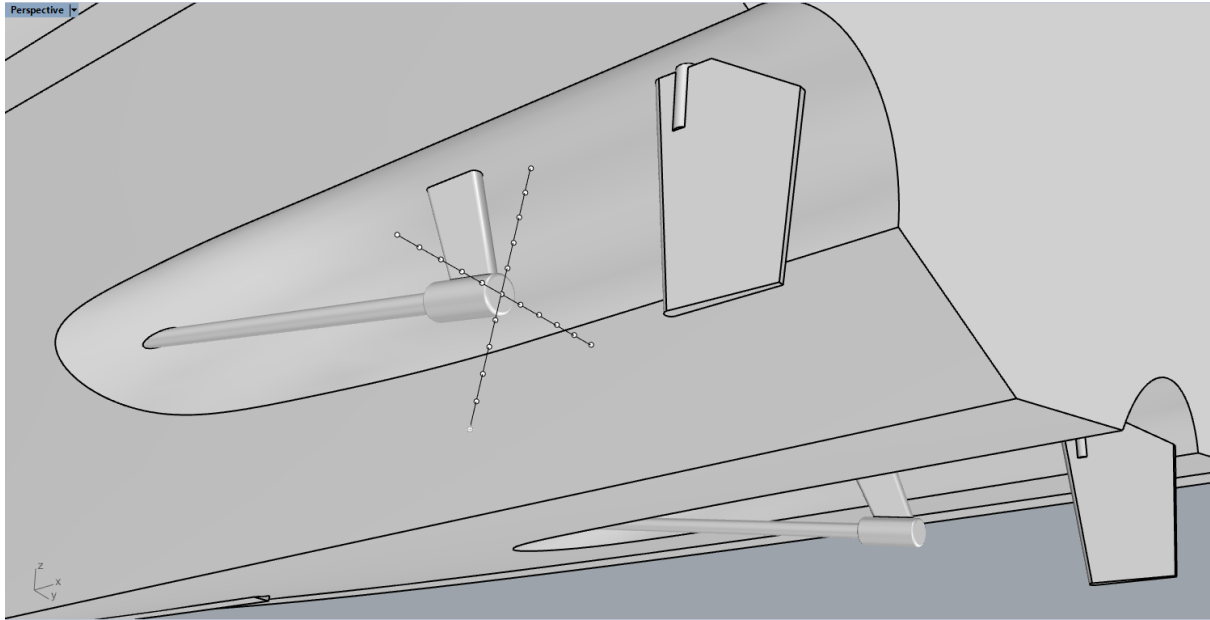
Description: Hydrostatics & Stability Analysis

☒ Weight(s) 10000 lbf or ☐ Model Sinkage(s) 0 ft
☒ LCG(s) 17.8 ft or ☐ Model Trim(s) 0 deg
☒ TCG(s) 0 ft or ☐ Model Heel(s) 0 deg
 VCG(s) 3.35 ft

☐ Override Initial Plane Height for Free Float Iteration 2.7543510629501 ft
☐ Mirror About Centerplane
☐ Add Plane(s) Representing Water Surface
☒ Transform Model to Resultant Condition
☐ Compute Righting Arm at these Heel Angles 0 e.g. 0,5,...,30,40,...,90
☐ Print Full Output for Heeled Conditions
☐ Also Write Output To CSV File C:\Users\leibman\Documents\Hydrostatics.csv
☐ Use Custom Conditions
 Sort Results By: Displacement

Pre-Float Calculate Cancel Add Objects... Points of Interest... Orca3D Units...

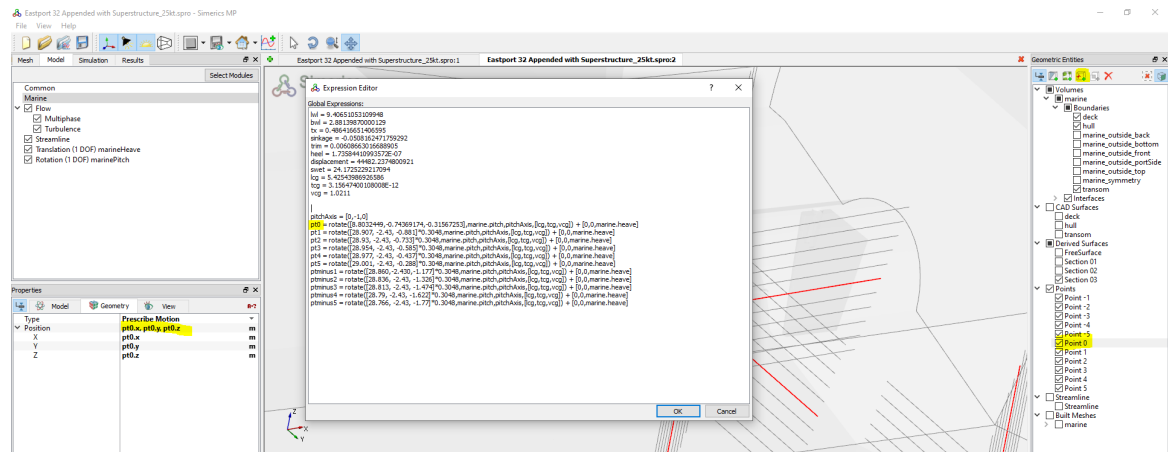
3. Next, create points distributed over the propeller plane as shown below. Here Rhino was used to draw a line from bottom to top of the propeller disk (note this line is not vertical but raked and perpendicular to the shaft line) as well as a line from port to starboard sides of the propeller disk. Then points were evenly distributed along these lines representing here increments of 20% of the propeller diameter. Of course you can use more or less point as desired as well as additional line segments as needed.



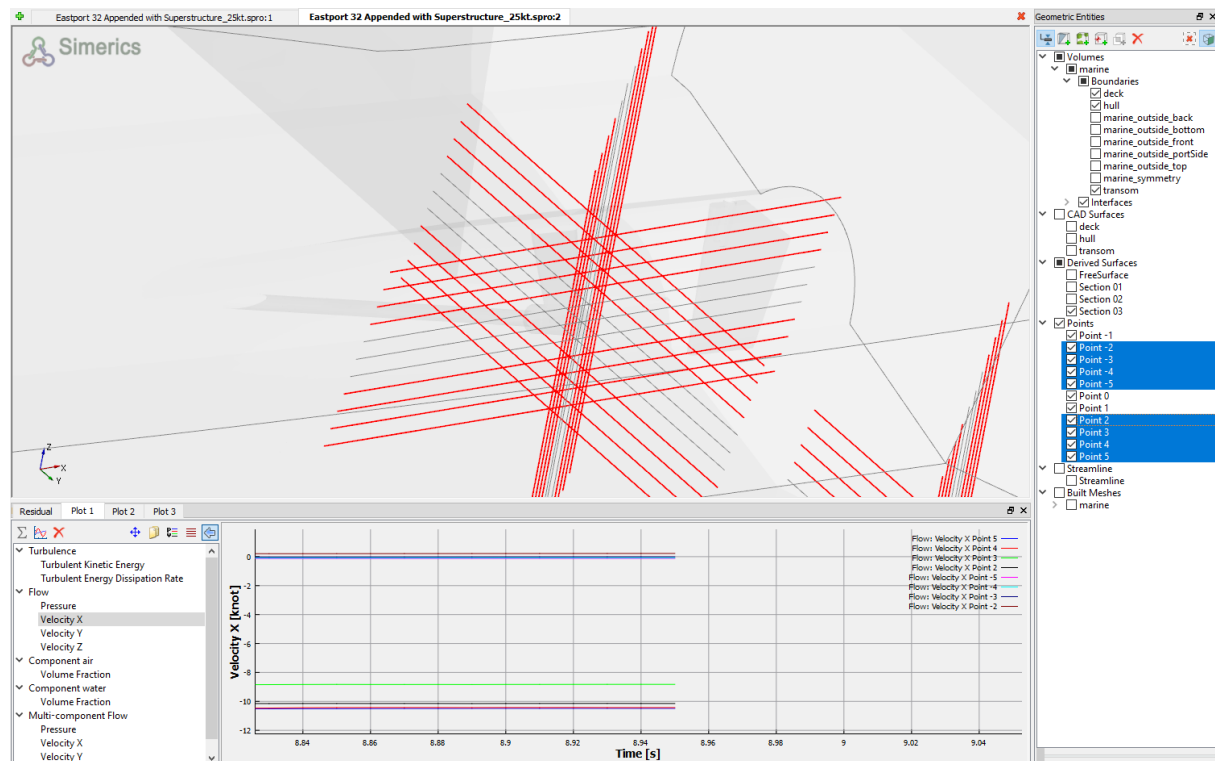
4. With Rhino still open, also open the CFD simulation in SimericsMP. As shown below use the highlighted toolbar button in the Geometric Entities panel to create as many monitoring points as you have points in the Rhino model. For clarity, in the figure below we only created the 11 monitoring points ("Point -5" through "Point 5") distributed along the line segment from bottom to top of the propeller disk.

a. Select one of the monitoring points in the Geometric Entities panel and then in the Geometry tab of the Properties panel change the Type to Prescribe Motion. We will specify the point location so that it moves with the heave and pitch of the vessel. Measure the corresponding point location in Rhino using the EvaluatePt command. This will provide the x, y, z coordinates of the point in the same coordinate system as SimericsMP since you transformed the model. However, this will be prior to any dynamic pitch and heave. Open the Expressions Editor and define an expression for the location of the point. The expression takes the measured position of the point in static equilibrium from Rhino, then rotates by the pitch angle about the CG then raises the point by the heave magnitude. You'll notice that for some of the points we multiplied the Rhino location by 0.3048 because the Rhino model is in ft units and the Simerics model is in SI units.

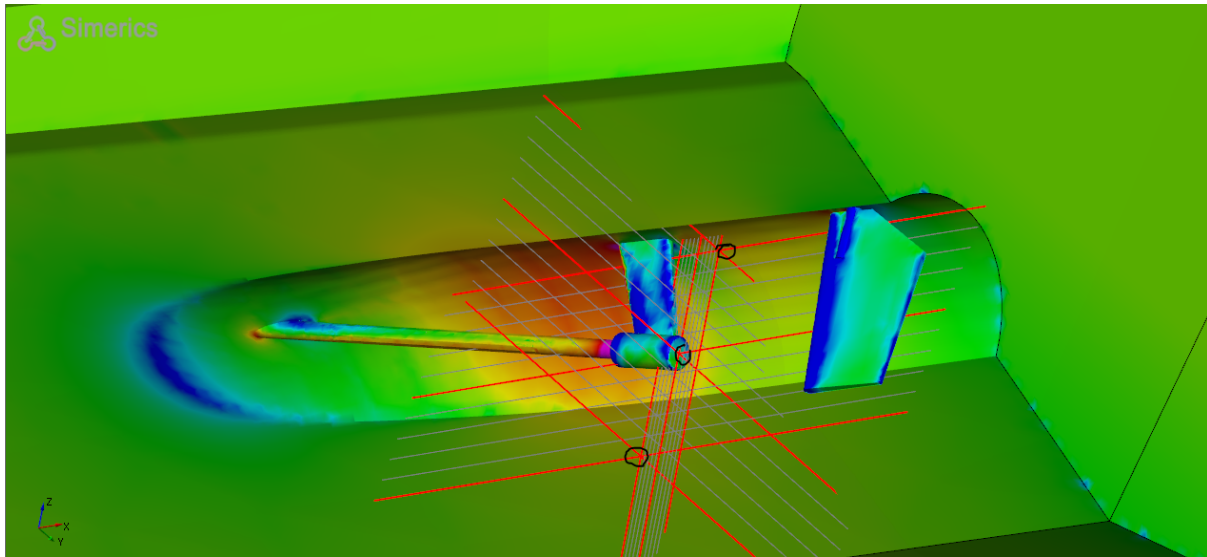
b. Close the expression editor and set the x, y, z values of the selected monitoring point to the associated expression variable. So for Monitoring Point "Point 0" we set the coordinates to [pt0.x, pt0.y, pt0.z] corresponding to the expression for that point. Now the point will move with the vessel.



5. Start the simulation. While the simulation is running create a new X-Y Plot. Select the points in the Geometric Entities panel, click Velocity X in the plot variables and click the Plot Selected Variables button to add these to the plot as shown below. The plotted values represent the flow velocity associated with each monitoring point. Note that the velocity is relative to the free stream velocity. So in the plot below, points -2 through -5, which are below the propeller centerline, are all clustered around 0 kt indicating that the wake fraction there is close to 1. On the other side points 2 through 5, which are above prop centerline are around -9 to -10 kt relative to the free stream velocity of 25 kt, yielding local wake fraction of around $15/25$ or 0.6. This is because these point locations are right behind the shaft strut where there is a significant wake deficit. To get a nominal wake fraction you would average all of the points radially and circumferentially.



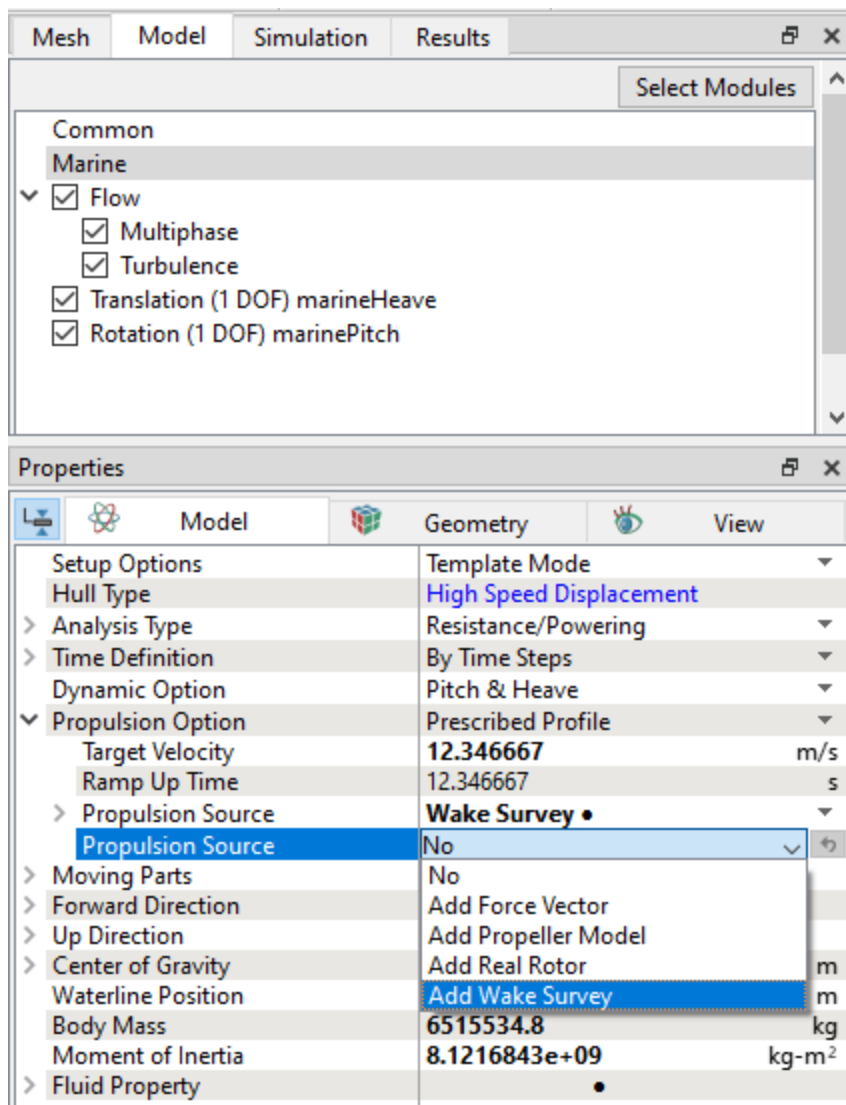
Finally the image below shows the dynamic pressure on the model along with monitoring points -5, 0, and 5 circled in black. The computed values of pressure and velocity components are output to the file *_points.txt in the Simerics project folder. You can use Excel to import and process these results.



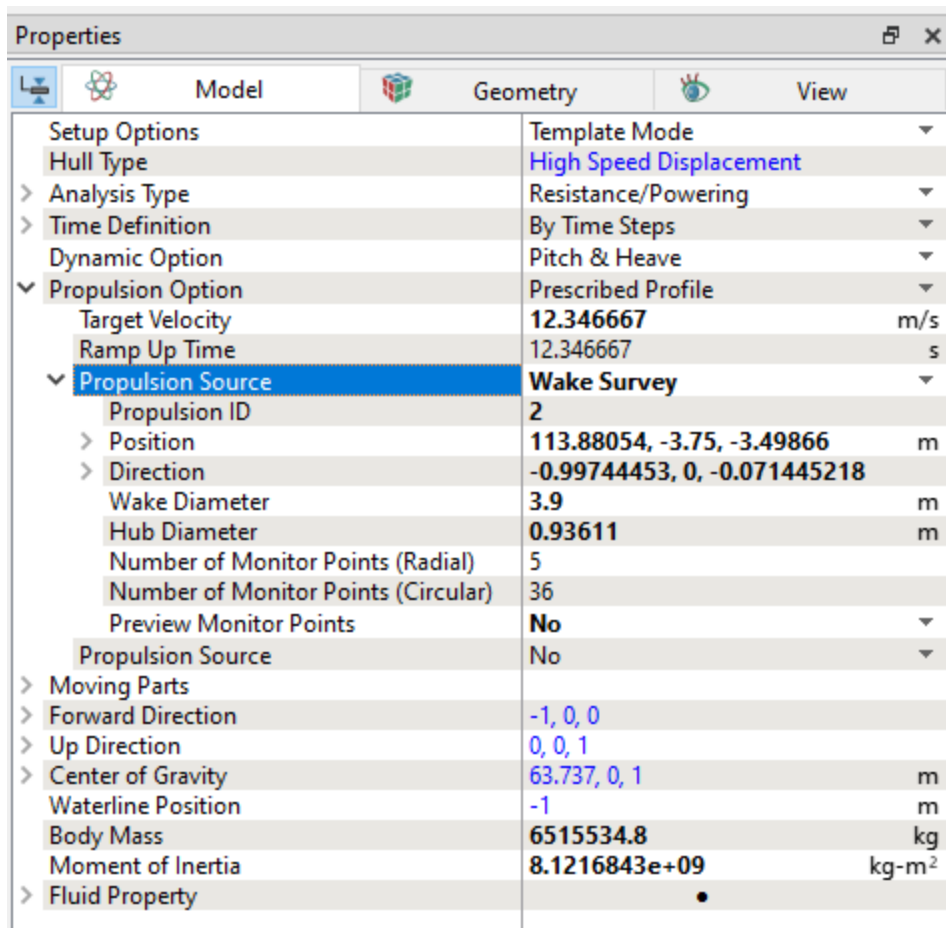
Semi-Automated Approach

To simulate a propeller wake survey with Orca3D Marine CFD using the semi-automated approach, the following steps should be performed:

1. As in the manual approach, first generate one or more CFD resistance simulations at the speeds of interest in the way you normally would with Orca3D Marine CFD. Wake measurements are traditionally made in resistance simulations with appendages but in the absence of the propeller.
2. As before, this approach uses monitoring points, but in this case the locations of the monitoring points are automatically computed for you. Once you open the resistance simulation in SimericsMP there is an option to set up a wake survey by adding a special Propulsion Source. As shown in the image below first select the "Marine" module in the Model panel and then in the Properties panel expand the Propulsion Option. Click on the dropdown and choose "Add Wake Survey" to add a new Wake Survey. This type of propulsion source is a special type in that it does not add any propulsive force to the simulation but instead allows some of the same inputs that are used to define a propeller to be specified along with others to define the disk within which the wake survey is desired.

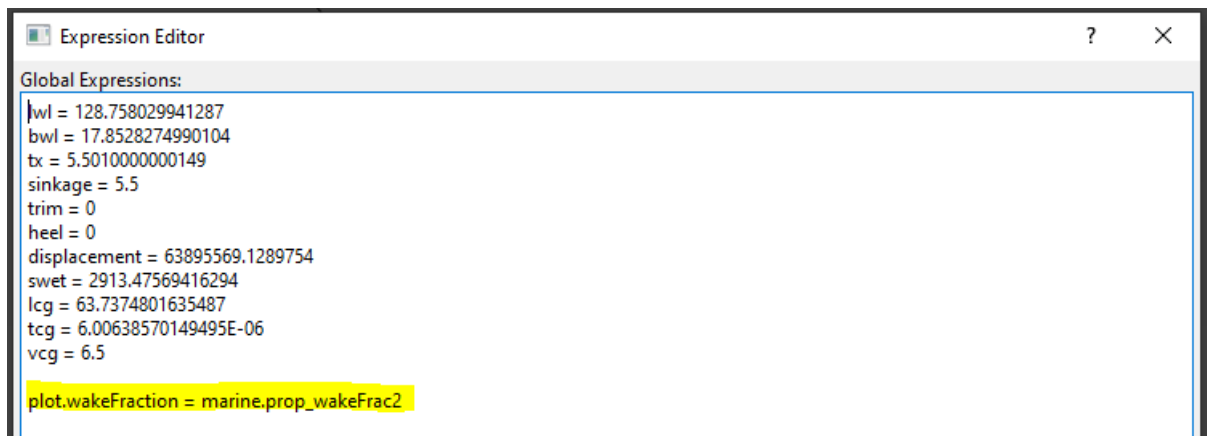


Once you've added the wake survey source, expanding it reveals the required input parameters as shown below. This consists of an integer ID, the "Position" which is generally the center of the propeller disk, the "Direction" defining the vector thrust direction of the propeller (x = -1 is forward), and the "Wake" and "Hub" diameters where the former is generally the same as the propeller diameter. Remember the the position and direction inputs are in the initial condition which corresponds to the static equilibrium condition computed in Orca. You can use the same technique of transforming the model to the resultant flotation condition described above in the "Manual Approach" if you would like to measure the location directly in Rhino. Two additional inputs include the number of monitoring points to create within the disk both radially and circumferentially.



After that is done you can select the "Preview Monitor Points" dropdown and select Yes to create the points. Alternatively they will be automatically created when you run the simulation.

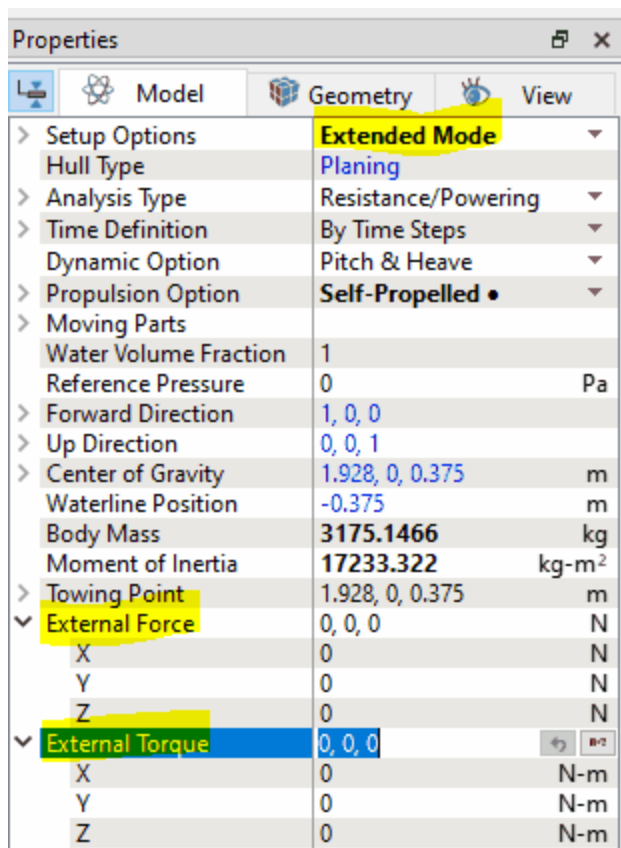
This is all that is required to define the locations of the monitoring points. However, one additional feature of the semi-automated approach described here is that SimericsMP will automatically perform an integration of the longitudinal flow velocities at each point to determine an average or "nominal" wake fraction. To plot the computed wake fraction you will need to define a custom plot variable as shown below. Note that the integer value "2" in that expression must match the ID of the WakeSurvey. This allows for multiple wake survey sources to be added if needed.



13.10.4 External Force or Moment

If you need to add an external force or moment to the analysis, you can add this in the Simerics interface before you start an analysis. These are applied at the towing point, which by default is the center of gravity.

In the Model tab, select the Marine module. In the Properties pane, change the Setup Options to Extended Mode:



Enter the X, Y, and Z components. Note that these can be the actual values, or an expression (for example, as a function of time). These should be the total values, even if you are doing a symmetric run.

If you need to specify a force at a different location than the towing point, you can add it as a Propulsion Source (even if you are doing a resistance run). See *Propulsion Options* in [Working with Settings in SimericsMP](#)^[433]. Note that with a Propulsion Source in a symmetric run, it is mirrored across the centerplane. Therefore, if the force is on the centerplane, you should enter 1/2 of the force in a symmetric run.

Part



14 Weight & Cost Tracking

The success of any design hinges on its weight and center of gravity (CG). These parameters are fundamental to stability, speed, capacity to carry cargo (whether it be passengers, containers, or weapons), seakeeping performance, etc. Weight and CG tracking therefore must be a fundamental part of any design process.

Cost is another critical factor in the success of a design, and good engineering practice calls for cost considerations to be closely tied to the design process.

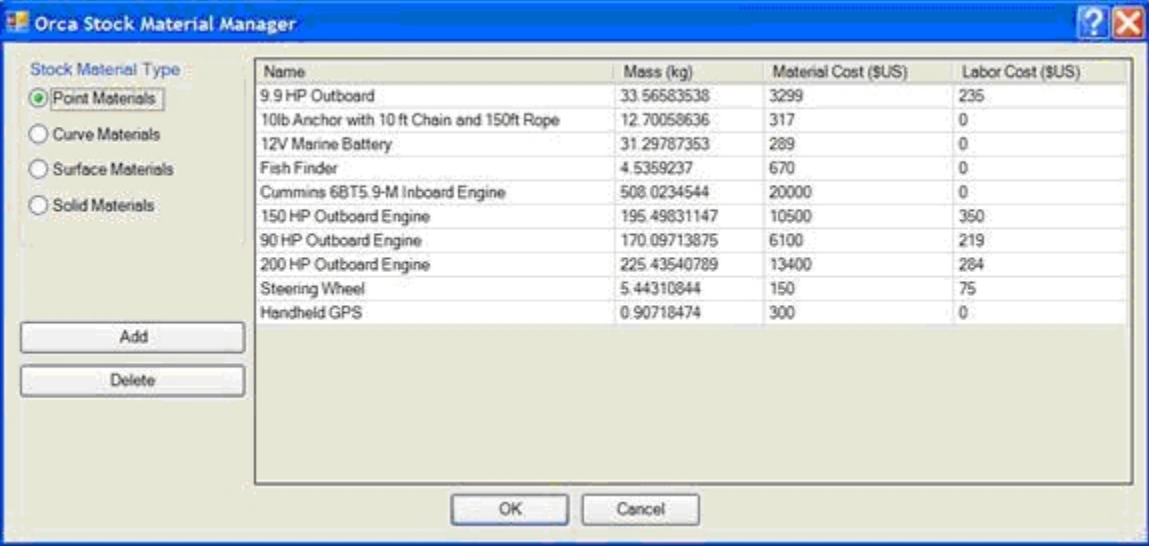
Orca3D allows you to track the overall weight, center of gravity, and cost of your model, by attaching weight and cost properties to individual objects (points, curves, surfaces, meshes, solids, polycurves, polysurfaces, lightweight extrusion objects, and blocks) in the model. These properties can be fixed values (for example, 28 kgs., or \$175), or can be weight or cost "densities" (for example, 3.8 kg/m², \$52.50/foot, etc.). Finally, a report can be generated summarizing the total weight, CG, and cost.

A library of standard materials can be created, which includes a name, weight or weight density, and/or cost or cost density. This makes it easy to assign stock materials to objects in your model.

14.1 Entering Stock Materials

Toolbar	
Menu	Orca3D > Weight/Cost > Manage Material Library
Command	OrcaManageStockMaterials

To simplify the process of assigning weight and cost properties to objects, you may create a library of stock materials, including point, curve, surface, and solid materials. For each material, you specify the name, weight property, and cost properties.



The Orca Stock Material Manager dialog box is shown. It has a title bar "Orca Stock Material Manager" with a question mark and close button. On the left, under "Stock Material Type", there are four radio buttons: "Point Materials" (selected), "Curve Materials", "Surface Materials", and "Solid Materials". Below these are "Add" and "Delete" buttons. The main area is a table with four columns: "Name", "Mass (kg)", "Material Cost (\$US)", and "Labor Cost (\$US)". The table contains the following data:

Name	Mass (kg)	Material Cost (\$US)	Labor Cost (\$US)
9.9 HP Outboard	33.56583538	3299	235
10lb Anchor with 10 ft Chain and 150ft Rope	12.70058636	317	0
12V Marine Battery	31.29787353	289	0
Fish Finder	4.5359237	670	0
Cummins 6BT5.9-M Inboard Engine	508.0234544	20000	0
150 HP Outboard Engine	195.49831147	10500	350
90 HP Outboard Engine	170.09713875	6100	219
200 HP Outboard Engine	225.43540789	13400	284
Steering Wheel	5.44310844	150	75
Handheld GPS	0.90718474	300	0

At the bottom of the dialog are "OK" and "Cancel" buttons.

In the case of a Point Material, the actual weight and cost are entered.

For a curve, the weight, material cost, and labor cost are entered per unit length. Similarly, surface and mesh materials are entered on a per unit area basis, and solids on a per unit volume basis.

The dialog box 'Orca Stock Material Manager' has a 'Stock Material Type' section on the left with four radio buttons: 'Point Materials', 'Curve Materials', 'Surface Materials' (which is selected), and 'Solid Materials'. Below these are 'Add' and 'Delete' buttons. The main table displays the following data:

Name	Mass/Area (kg/m...)	Material Cost/Area (\$U...)	Labor Cost/Area (\$U...)
3/16" Aluminum	35.153478981958	85.0348922920068	93.6460206253746
Tempered Glass	6.347155927297	46	36
1-1/2in STD Steel Pipe	135.2432455278	4	2.4
1" Aluminum Pipe	22.459167127362	3	1.39
0.306in Fiberglass	19.52971054553	97	102
102	23.923895418277	104	102
0.75in Fiberglass	39.54766385470	117	102

At the bottom are 'OK' and 'Cancel' buttons.

The dialog box 'Orca Stock Material Manager' has a 'Stock Material Type' section on the left with four radio buttons: 'Point Materials', 'Curve Materials', 'Surface Materials', and 'Solid Materials' (which is selected). Below these are 'Add' and 'Delete' buttons. The main table displays the following data:

Name	Mass/Volume (kg...)	Material Cost/Volume (...)	Labor Cost/Volume (...)
Sea Water	1025.181655933	0	0
Diesel	849.4591127211	1412.58666885954	0
Unleaded Gasoline	727.7187910790	1236.0133352521	0
Fresh Water	993.1447291855	0	0

At the bottom are 'OK' and 'Cancel' buttons.

The Material Name does not have to be unique; each material has a unique identifier that is not shown.

The Stock Material Library is contained in a file on your computer (by default, C:\Documents and Settings\All Users\Application Data\DRSC3ATC\Orca3D\StockMaterialLibrary.xml), and so is available any time you are using Orca3D. Any materials that are used in a model are also stored with the 3dm file. If a material is updated in the Stock Material Library, and then a model that uses that material is opened in Rhino, Orca3D will automatically update the object to reflect the new data from the Stock Material Library. See [Exporting & Merging](#)


[Material Libraries](#)

If a 3dm file is read that has objects with weight/cost properties that are not included in your library, the properties will remain with the objects and will be used in the computation and reporting of the total weight, CG, and cost. In the Material Library section of the report, the material names will be preceded with (local).

If you import or insert a Rhino model which has weight/cost properties into another Rhino model, you have the option of merging the weight/cost data.

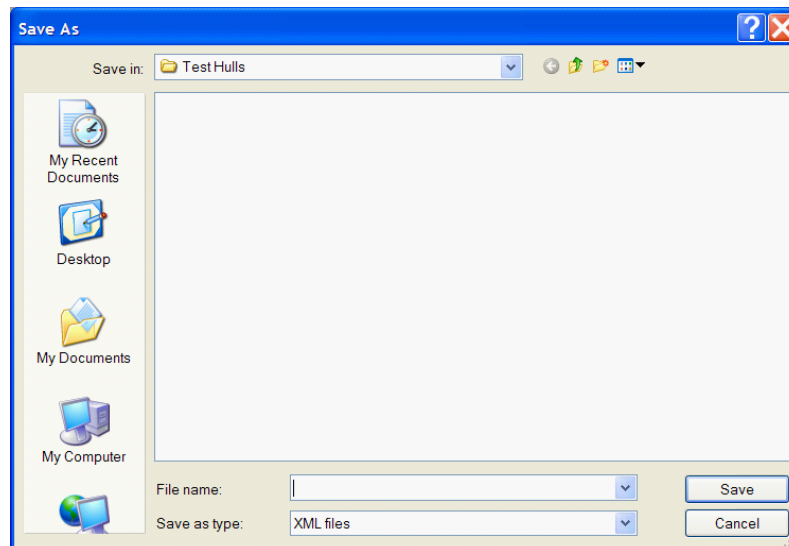
If you give your 3dm file to another Rhino user who does not have Orca3D Weight & Cost Tracking, the data will remain intact so long as the object is not deleted. If the other user does have the Weight & Cost module, the Material Properties will be shown on the objects, but will not be shown in the other user's Stock Material Manager. In the Material Library section of the report, the material names will be preceded with (local).

14.2 Exporting & Merging Material Libraries


Toolbar	
Menu	Orca3D > Weight/Cost > Export Material Library
Command	OrcaExportStockMaterialLibrary

Orca3D allows you to export your stock material library from your computer and merge it with a stock material library on another computer.

1. Start the command with the toolbar icon, menu selection or keyboard command.
2. A dialog will open allowing you to give the library a name and select a location to save the file to.



Your library can be saved either as an .XML file or a .CSV in the location specified. This file can now be sent to another computer to be merged with another material library.

Toolbar	
Menu	Orca3D > Weight/Cost > Merge Material Library
Command	OrcaMergeStockMaterialLibrary

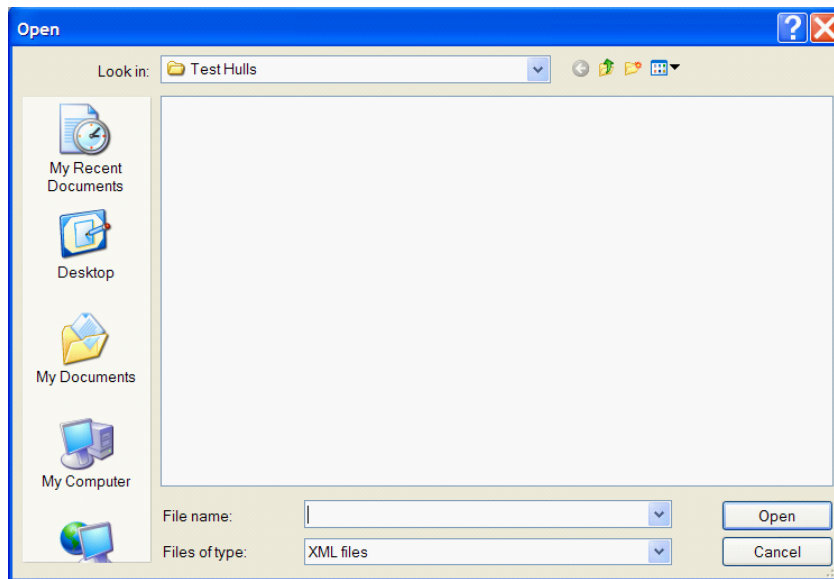
The command to merge a stock material library is used to import materials from another Orca3D user, or if you would rather build/edit your library in Excel. If the library is being merged from another Orca3D user, XML is the best format to use. The other user would export their library (as described above), and you would simply merge it into yours.

If you want to create or edit a stock material library in Excel, the easiest way to start is to first export your stock material library (as a csv file), as described above, and then use Excel to edit the file. The file begins with some unit conversion information, which you should leave as-is. This is followed by the material information, and for each stock material item includes:

- Material Name: any alphanumeric string
- Material UUID: If you are adding new objects, leave this blank. If you are editing an object (so that it will replace the original), leave this field as-is.
- Material Type: must be point, curve, surface, or solid
- Mass Constant: for points, the weight; for curves, surfaces, or solids, the weight per unit length, area, or volume respectively. May be entered as zero, but cannot be blank.
- Material Cost Constant: for points, the material cost; for curves, surfaces, or solids, the material cost per unit length, area, or volume respectively. May be entered as zero, but cannot be blank.
- Labor Cost Constant: for points, the labor cost; for curves, surfaces, or solids, the labor cost per unit length, area, or volume respectively. May be entered as zero, but cannot be blank.

Save the file in CSV format, and then use the OrcaMergeStockMaterialLibrary command to merge it.

1. Start the command with the toolbar icon, menu selection or keyboard command.
2. A dialog will open allowing you to select the exported material library file. You can select a file type of .XML or .CSV.



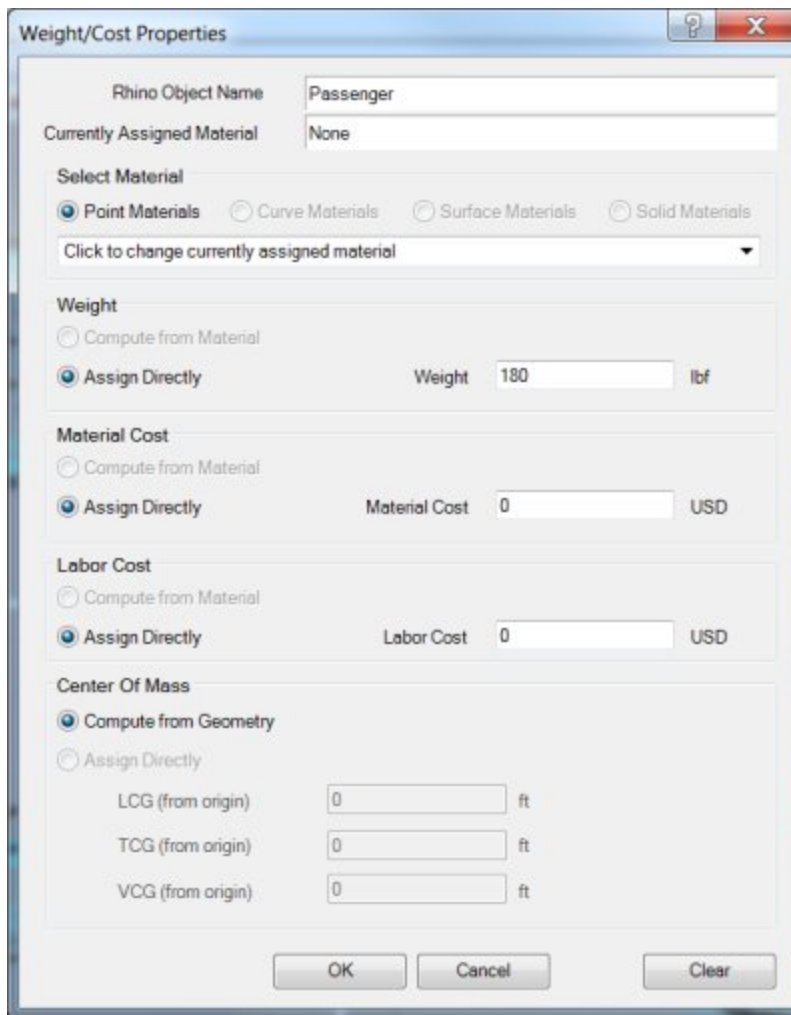
3. Click Open to merge the library with the current library.

The new library file will now include object properties from the original and merged library. When importing materials, an attempt is made to compare the imported materials with existing materials (either by unique identifier or by name which is not unique) and allow the user to determine if existing materials are to be replaced or new materials are to be added.

14.3 Assigning Weight/Cost Properties

Toolbar	
Menu	Orca3D > Weight/Cost > Assign Weight/Cost Properties
Command	OrcaAssignWeightCost

Any point, curve, surface, mesh, solid, polycurve, polysurface, lightweight extrusion object, block, or solid object in the model may have Weight and/or Cost properties assigned to it:



The image shows the 'Weight/Cost Properties' dialog box in a software application. The dialog has a title bar with a question mark and a close button. It contains several sections for configuring object properties:

- Rhino Object Name:** A text field containing 'Passenger'.
- Currently Assigned Material:** A dropdown menu showing 'None'.
- Select Material:** Four radio buttons: 'Point Materials' (selected), 'Curve Materials', 'Surface Materials', and 'Solid Materials'. Below them is a dropdown menu with the text 'Click to change currently assigned material'.
- Weight:** Two radio buttons: 'Compute from Material' and 'Assign Directly' (selected). To the right is a 'Weight' field with the value '180' and a unit dropdown set to 'lbf'.
- Material Cost:** Two radio buttons: 'Compute from Material' and 'Assign Directly' (selected). To the right is a 'Material Cost' field with the value '0' and a unit dropdown set to 'USD'.
- Labor Cost:** Two radio buttons: 'Compute from Material' and 'Assign Directly' (selected). To the right is a 'Labor Cost' field with the value '0' and a unit dropdown set to 'USD'.
- Center Of Mass:** Two radio buttons: 'Compute from Geometry' (selected) and 'Assign Directly'. Below are three fields: 'LCG (from origin)' with value '0', 'TCG (from origin)' with value '0', and 'VCG (from origin)' with value '0', each with a unit dropdown set to 'ft'.

At the bottom are three buttons: 'OK', 'Cancel', and 'Clear'.

After starting the command and selecting the object, you will see the Weight/Cost Properties dialog. At the top, you may select any applicable materials type (Point, Curve, Surface, or Solid), depending on the type of object(s) that you have selected. Material properties may be assigned as follows:

	Point Object	Curve Object	Polyc urve Object	Mesh Object	Poly mesh Object	Surfa ce Object	Polys urfac e Object	Solid Object
Point Mater ial	✓	✓	✓	✓	✓	✓	✓	✓
Curve Mater ial		✓	✓					

Surface Material				✓	✓	✓	✓	
Solid Material								✓

If you have selected multiple objects, only those Material properties that are common to all of the objects will be allowed. For example, if you select a curve and a surface, you can only assign a Point Material to them.

Once you have selected the type of material, select your material from the drop down list. If you would like to define a new stock material, select "Add new materials..." from the drop down list.

If you want the weight, material cost, and labor cost to be computed from the definition of the material and the geometry of the object, select "Compute from Material." For example, if you are working with a surface object, and select a material that weighs 2 kg/m², if the object has a surface area of 3 m², the weight will be 6 kgs. As the object is modified, the weight will update automatically.

If you wish to specify a weight and cost directly, select "Assign Directly." In this case, modifying your object will not change its weight or cost. You may assign a negative weight to an object, but a warning will be issued to confirm that this is intended.

You can allow Orca3D to compute the center of gravity of an object and update it as it is moved, or you can assign its value. *Note that if you assign the CG directly, moving the object in the Rhino model will not change these values.*

If you need to clear the weight/cost properties that have been assigned previously to an object, click the Clear button. This will not delete your stock material definition; it will only clear the weight/cost properties from the selected object(s).

Assigning Properties to Multiple Objects

It's important to understand how Orca3D assigns Material Properties to multiple objects, groups, polycurves and polysurfaces (poly-objects), and what happens when objects are joined or exploded.

Point Materials:

- When multiple objects are selected, and a Point Material is assigned, it is as if you had selected each object individually and assigned the Point Material. If you select 2 curves and 3 surfaces and assign a Point Material that weighs 1 kg to all of them, you now have 5 kgs of weight. The same is true if you have selected a group; each object in the group is individually assigned the Point Material.
- When you assign a Point Material to a polycurve or polysurface, it is assigned to the

entire poly-object, not the underlying curves or surfaces that make up that object. For example, if you assign a 1 kg Point Material to a polysurface that is made up of 20 surfaces, you have 1 kg of weight.

- If you then explode the poly-object, each new object is assigned the Point Material. In the above example, each of the 20 surfaces would now have a weight of 1 kg, for a total of 20 kgs.

Curves, Surface, and Solid Materials:

- When multiple objects, groups, or poly-objects are selected and assigned a Curve, Surface, or Solid Material property, they are each assigned the property.
- Since these properties are "densities," based on the length, area, or volume, it doesn't matter if they are grouped, joined into poly-objects, or exploded. The total weight/cost will remain the same. The exception to this is when a solid object (which in Rhino is really a closed polysurface) is exploded into surfaces; at that point, it loses its Solid Material property and the surfaces will have no weight or cost properties.

Blocks

A Rhino block can be made up of combinations of any type of object (points, curves, surfaces, etc.). If the objects have Material Properties assigned to them when the block is created, the block definition will maintain these properties, so that when more instances of the block are created, the Material Properties will be included. You cannot assign weight/cost properties to the individual block instances, only to the block definitions. If you want to change a weight/cost property on the definition you can explode one of the instances, change a weight/cost property on one or more of the objects in the block, then recreate the block instance being sure to use the same block definition name so that it will replace the old block definition (and thus propagate to the other block instances). Nested blocks work in a similar fashion.

In the Weight & Cost Report, each instance of the block will be included, and at the end of the report, a list block definitions will be included. For each block, this shows a list of the individual objects and their Material Properties. When a block is exploded, the Material Properties will remain on the individual objects, but they will no longer be tied to the block definition.

Importing & Inserting Files

If you **Import** another file into the model, the weight/cost properties will be imported automatically. If the imported file references Stock Material Library entries that are not in your Stock Material Library, they will be considered "[local material properties](#)⁴⁶⁸."

If you **Insert** another file into the model, you are given three options as to how the objects are added to your model:

- As Objects: this is functionally identical to importing a model

- As a Group: similar to importing, but the objects are grouped into one group. Their weight/cost properties remain intact.
- As a Block Instance: Blocks may be linked, linked & embedded, or embedded. If they are embedded, the material properties are imported, just as if you had imported the model. If they are linked, the material properties are imported, but the link to the material properties is broken. If the original model is changed, the linked block will update accordingly. But if the material properties are changed in the original file, that information will not be updated in your model (i.e., *the link to the material properties is broken*).

14.4 Modifying Objects with Weight/Cost Properties

Once an object is assigned a material property, that property will stay with the object through most typical Rhino operations as long as the original object is left independent of other Rhino objects. Such 'typical' Rhino operations include all direct manipulation, trimming, and rebuilding. Additionally, all duplicates of that object will be assigned the same material property as the original object. Excepting block instances, once an object is duplicated, any properties of the new object are independent of the source object and will not reflect property reassignments on the source.

If an object having a material property undergoes a change to break it down into its constituent parts (such as surfaces from a polysurface) or split into multiple pieces, each of those objects will retain the same material property that was assigned to the original object, provided that material property is still applicable to the new object type. If the material property is incompatible with the new object type, no material property will be assigned. For example, if a closed polysurface with a solid material type is exploded into its individual surfaces, none of these surfaces would have a material property as the solid material type is incompatible with surface objects.

When Rhino objects are joined to form a composite assembly, such as a polysurface, the resulting composite will take the material property of the last object edited in Rhino, including both object creation and manipulation. If the last object edited does not have an assigned material property, then the composite will likewise not have one.

It is good practice, after joining or exploding objects, to verify that the resulting object(s) have the proper material property assigned, either by selecting the object and using the Assign Weight/Cost Properties command, or using the Manage Weight/Cost Properties command.

14.5 Managing Weight and Cost Properties

To help in managing the assignment of weight and cost properties to the objects in the model, Orca3D provides a function to help you see what objects have Material Properties assigned, and a tabular view of the objects with Material Properties.

Selecting Objects with Material Properties

Toolbar	<i>n/a</i>
Menu	Orca3D > Weight/Cost > Select
Command	OrcaSelWeightCost

This selection command has four options:

- Select objects **with** Material Properties
- Select objects **without** Material Properties
- Select objects by Material type (point, curve, surface, solid, none)
- Select objects by Material name

Notes:

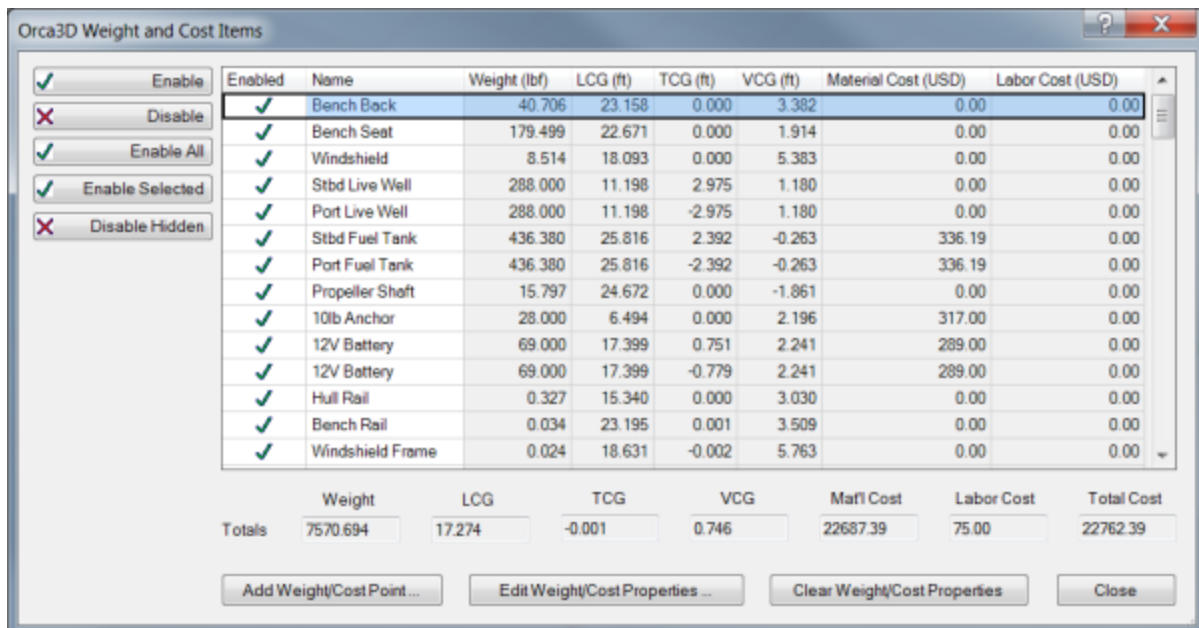
- Like other selection commands in Rhino, objects that are hidden, locked, or on layers that are turned off will not be selected.
- Objects that do not have Material Properties, but are part of a block instance where at least one object in the block has Material Properties, will be selected since the entire block is selected.

Using this command, you can quickly check your model to see if any objects do not yet have Material Properties assigned.

Tabular View of the Objects with Material Properties

Toolbar	<i>n/a</i>
Menu	Orca3D > Weight/Cost > Manage Weight/Cost Properties
Command	OrcaManageWeightCost

This command brings up a tabular view, listing all of the objects in the model that have Material Properties assigned to them. For each object, the name, weight, CG, and cost data is shown, and at the bottom, the totals are displayed for each column. (Objects can be assigned a name through the [Orca3D Tree](#)¹⁶⁶, or Rhino's Properties dialog).



The image shows the 'Orca3D Weight and Cost Items' dialog box. It features a list of items with columns for 'Enabled', 'Name', 'Weight (lbf)', 'LCG (ft)', 'TCG (ft)', 'VCG (ft)', 'Material Cost (USD)', and 'Labor Cost (USD)'. On the left, there are buttons for 'Enable', 'Disable', 'Enable All', 'Enable Selected', and 'Disable Hidden'. At the bottom, there are summary fields for 'Weight', 'LCG', 'TCG', 'VCG', 'Mat'l Cost', 'Labor Cost', and 'Total Cost', along with buttons for 'Add Weight/Cost Point...', 'Edit Weight/Cost Properties...', 'Clear Weight/Cost Properties', and 'Close'.

Enabled	Name	Weight (lbf)	LCG (ft)	TCG (ft)	VCG (ft)	Material Cost (USD)	Labor Cost (USD)
✓	Bench Back	40.706	23.158	0.000	3.382	0.00	0.00
✓	Bench Seat	179.499	22.671	0.000	1.914	0.00	0.00
✓	Windshield	8.514	18.093	0.000	5.383	0.00	0.00
✓	Stbd Live Well	288.000	11.198	2.975	1.180	0.00	0.00
✓	Port Live Well	288.000	11.198	-2.975	1.180	0.00	0.00
✓	Stbd Fuel Tank	436.380	25.816	2.392	-0.263	336.19	0.00
✓	Port Fuel Tank	436.380	25.816	-2.392	-0.263	336.19	0.00
✓	Propeller Shaft	15.797	24.672	0.000	-1.861	0.00	0.00
✓	10lb Anchor	28.000	6.494	0.000	2.196	317.00	0.00
✓	12V Battery	69.000	17.399	0.751	2.241	289.00	0.00
✓	12V Battery	69.000	17.399	-0.779	2.241	289.00	0.00
✓	Hull Rail	0.327	15.340	0.000	3.030	0.00	0.00
✓	Bench Rail	0.034	23.195	0.001	3.509	0.00	0.00
✓	Windshield Frame	0.024	18.631	-0.002	5.763	0.00	0.00

	Weight	LCG	TCG	VCG	Mat'l Cost	Labor Cost	Total Cost
Totals	7570.694	17.274	-0.001	0.746	22687.39	75.00	22762.39

Enabling and Disabling Objects

Any object in the list may be "enabled" or "disabled." When an item is enabled, it will be included in the Weight & Cost Report, and will be included in the total weight and CG used in design hydrostatics when the ["Link to Orca3D Weight/Cost Items"](#)¹³⁴ box is selected, or in general hydrostatics/stability calculations [when the Weight icon is selected](#)²⁶².

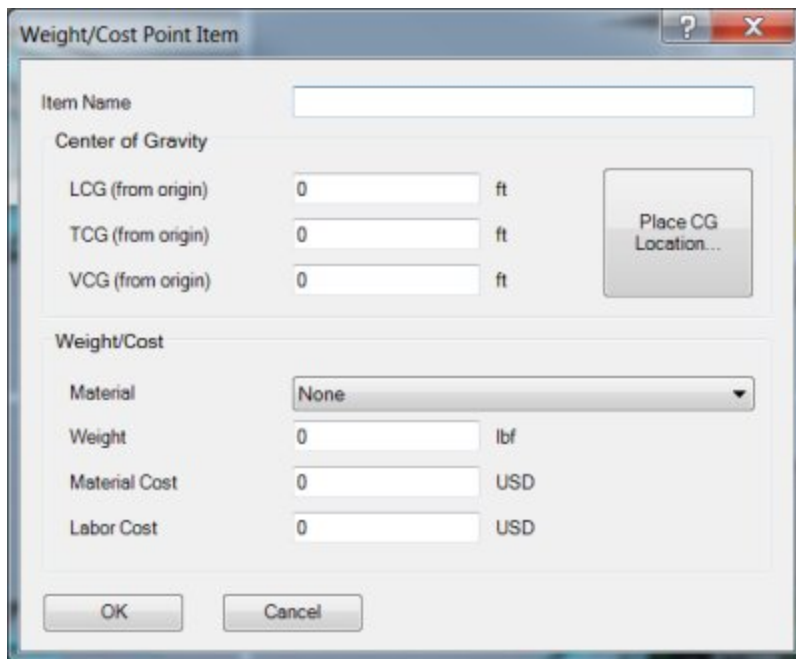
However, there may be times when an object should not be included in a report or in hydrostatic calculations. For example, your model may contain two different versions of the same object, such as two different engine options, and only one or the other would be on the vessel as-built. In this case, you should select the item to be disabled in the list, and click on the "Disable" button.

If your model contains a lot of hidden objects and you want to be sure that these are not included in the Weight & Cost Report or hydrostatics calculations, you can select the "Disable Hidden" button.

Any objects that are currently selected in your model can be enabled by clicking on the "Enable Selected" button.

Add Weight/Cost Point

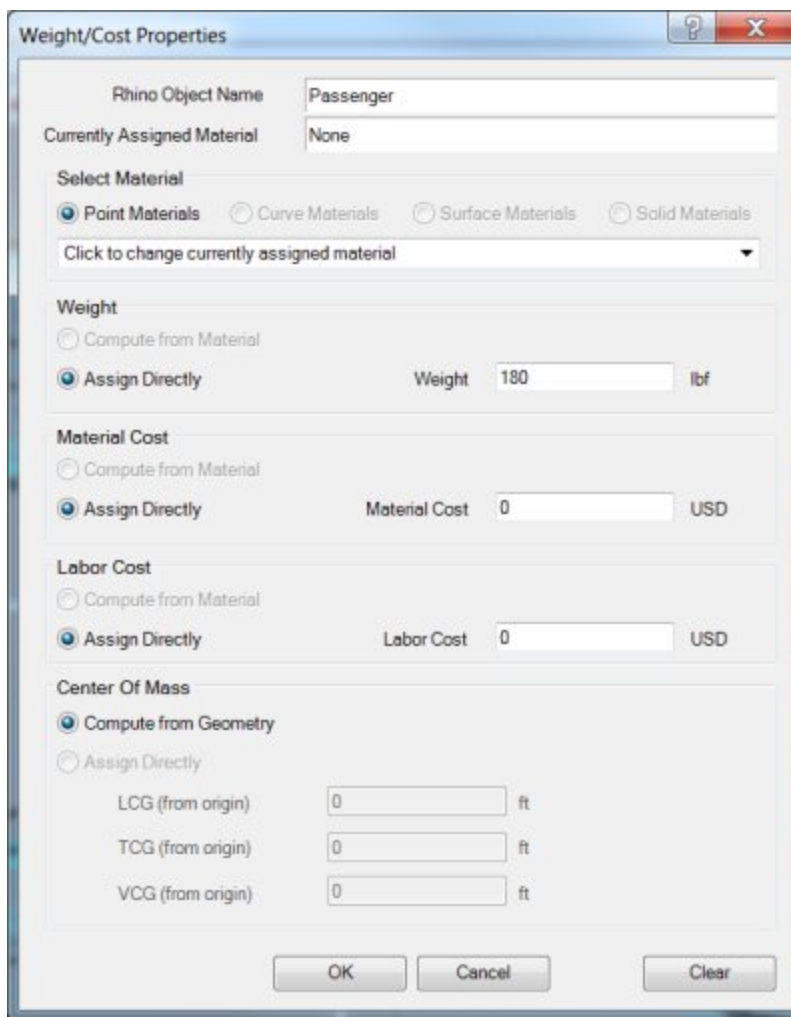
To add a point object to the model with weight and cost data, click on Add Weight/Cost Point. The following dialog will be shown:



The image shows a software dialog box titled "Weight/Cost Point Item". It contains several input fields and buttons. At the top is an "Item Name" text box. Below it is a "Center of Gravity" section with three rows: "LCG (from origin)", "TCG (from origin)", and "VCG (from origin)". Each row has a numeric input field set to "0" and a unit label "ft". To the right of these fields is a button labeled "Place CG Location...". Below the "Center of Gravity" section is a "Weight/Cost" section. It starts with a "Material" dropdown menu currently set to "None". Below this are three rows: "Weight" with a numeric input field set to "0" and a unit label "lbf"; "Material Cost" with a numeric input field set to "0" and a unit label "USD"; and "Labor Cost" with a numeric input field set to "0" and a unit label "USD". At the bottom of the dialog are two buttons: "OK" and "Cancel".

Edit Weight/Cost Properties

Select one or more objects in the list, and click on Edit Weight/Cost Properties. The Weight/Cost properties dialog will be shown. See [Assigning Weight/Cost Properties](#)⁴⁷⁰.



The image shows the 'Weight/Cost Properties' dialog box in Orca3D. It has a title bar with a question mark and a close button. The dialog is divided into several sections:

- Rhino Object Name:** A text field containing 'Passenger'.
- Currently Assigned Material:** A text field containing 'None'.
- Select Material:** A section with four radio buttons: 'Point Materials' (selected), 'Curve Materials', 'Surface Materials', and 'Solid Materials'. Below them is a dropdown menu with the text 'Click to change currently assigned material'.
- Weight:** A section with two radio buttons: 'Compute from Material' and 'Assign Directly' (selected). To the right of 'Assign Directly' is a text field for 'Weight' containing '180' and a unit dropdown set to 'lbf'.
- Material Cost:** A section with two radio buttons: 'Compute from Material' and 'Assign Directly' (selected). To the right of 'Assign Directly' is a text field for 'Material Cost' containing '0' and a unit dropdown set to 'USD'.
- Labor Cost:** A section with two radio buttons: 'Compute from Material' and 'Assign Directly' (selected). To the right of 'Assign Directly' is a text field for 'Labor Cost' containing '0' and a unit dropdown set to 'USD'.
- Center Of Mass:** A section with two radio buttons: 'Compute from Geometry' (selected) and 'Assign Directly'. Below these are three text fields for 'LCG (from origin)', 'TCG (from origin)', and 'VCG (from origin)', each containing '0' and a unit dropdown set to 'ft'.

At the bottom of the dialog are three buttons: 'OK', 'Cancel', and 'Clear'.

Clear Weight/Cost Properties

To remove Material Properties from one or more objects, select the desired object(s) from the list and click on Clear Weight/Cost Properties. This will remove the Material Properties from the object(s). The object(s) will remain in the model.

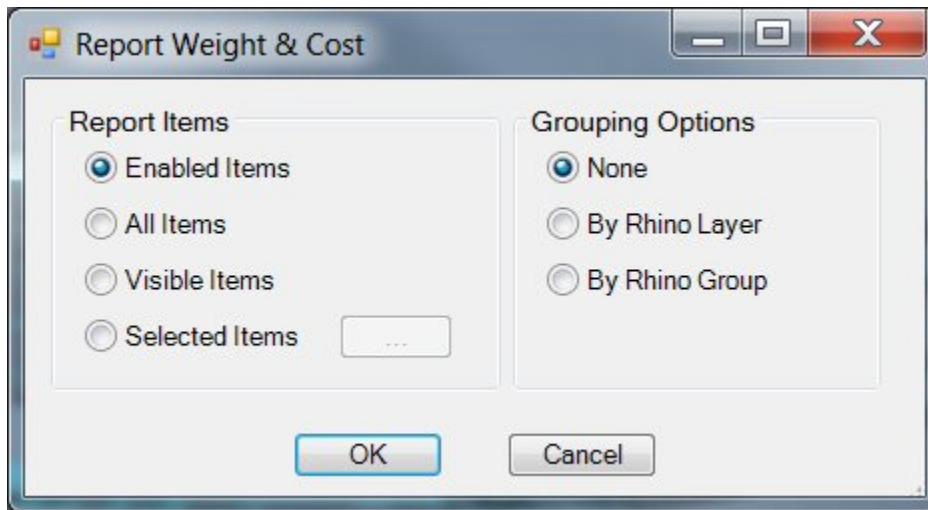
14.6 Weight/Cost Reporting

Toolbar	
Menu	Orca3D > Weight/Cost > Generate Weight/Cost Report
Command	OrcaReportWeightAndCost

To create a report summarizing the overall weight and cost of your model, select Generate Weight/Cost from the Orca3D Weight/Cost menu.

You can select to include **All** of the Items in the model that have weight/cost properties, just the **Visible Items** with weight/cost properties, or just the **Selected Items** with weight/cost properties. Finally, you can select the **Enabled Items**; whether an item is enabled is controlled in the Weight and Cost Items dialog, accessed with the [Manage Weight and Cost Properties](#)⁴⁷⁴ menu item.

Next, you select how to group the items in the report; selecting None will simply list all of the items. Grouping by Rhino Layer will summarize the items according to their layer, and grouping by Rhino Group will summarize according to any Groups that you have created with Rhino's Group command.



Click OK, and after a moment, the report will be shown. The first section summarizes the weight and CG of the model, the second contains cost information, and finally the Material Library data that was used in the report is tabulated. If the model contained Materials that are not in your library (for example, the model was created by somebody else), the Material Name will be preceded by (local).

Orca3D Weight And Cost Report

26' Center Console

Orca3D Weight and Cost Report

Orca3D

Report Time: 11/3/2011 5:01:24 PM

Model Name: C:\Users\bhays\Documents\Rhino\Center Console Fisherman.3dm

Object Name	Material	Weight (lbf)	LCG (ft)	TCG (ft)	VCG (ft)	Weight Basis
Helm Bench Support	1/8" Aluminum	1.677	18.575	-0.008	3.544	0.951 ft ²
Bow cushions	Cushion	9.601	6.283	-1.800	2.325	1.130 ft ³
Bow cushions	Cushion	9.601	6.283	1.800	2.325	1.130 ft ³
Helm Bench	Cushion	10.287	17.604	-0.008	2.501	1.210 ft ³
Helm Bench	Cushion	5.423	18.430	-0.008	3.285	0.638 ft ³
Forward Bench	Topsides	62.430	11.753	0.000	1.500	20.165 ft ²
Console	Topsides	330.480	14.059	-0.197	2.821	106.744 ft ²
Console Door	Topsides	43.803	13.942	1.763	2.489	14.148 ft ²
Windshield	1/4" Acrylic	4.298	14.695	1.564	5.409	2.791 ft ²

If the report was to be grouped according to Rhino Layer, it is shown as follows. Each layer

may be expanded by clicking on the + sign next to the layer name.

Orca3D Weight And Cost Report

26' Center Console

Orca3D Weight and Cost Report

Orca3D

Report Time: 11/3/2011 5:05:20 PM

Model Name: C:\Users\bhays\Documents\Rhino\Center Console Fisherman.3dm

Weight Items

Object Name	Material	Weight (lbf)	LCG (ft)	TCG (ft)	VCG (ft)	Weight Ba
<input type="checkbox"/> Layer: Fiberglass Top						
SubTotal		53.171	15.602	0.000	8.287	
<input type="checkbox"/> Layer: Outer						
SubTotal		1053.188	14.231	0.000	0.369	
<input type="checkbox"/> Layer: Inner						
SubTotal		990.312	14.403	0.000	1.624	
<input type="checkbox"/> Layer: Bow Rail						
SubTotal		19.968	4.805	0.000	4.797	
<input type="checkbox"/> Layer: Frame						
SubTotal		85.048	14.919	0.000	6.606	
<input type="checkbox"/> Layer: 250 (x2)						
SubTotal		1010.000	26.844	0.000	1.795	
<input type="checkbox"/> Layer: Rub Rail						

This report may printed, or saved as a PDF or Excel file.

Microsoft Excel - Weight And Cost Report.xls

File Edit View Insert Format Tools Data Window Help

Default Project

Orca3D Weight and Cost Report

Default Company

Report Time: 11/3/2009 10:03:59 AM

Material Library - Point Materials

Material Name	Mass (lbm)	Material Cost (USD)	Labor Cost (USD)
(local) Steering Wheel	12.000	150.00	75.00
(local) Handheld GPS	2.000	300.00	0.00
(local) Fish Finder	10.000	670.00	0.00
(local) Cummins 6BT5.9-M	1120.000	20000.00	0.00
Inboard Engine			
(local) 12V Marine Battery	69.000	289.00	0.00
(local) 10lb Anchor with 10 ft Chain and 150ft Rope	28.000	317.00	0.00

Material Library - Curve Materials

Material Name	Mass/Length (lbm/ft)	Material Cost/Length (USD/ft)	Labor Cost/Length (USD/ft)
(local) 1" Steel Propeller Shaft	1.680	0.00	0.00

Material Library - Surface Materials

Material Name	Mass/Area (lbm/ft^2)	Material Cost/Area (USD/ft^2)	Labor Cost/Area (USD/ft^2)
(local) 0.54in. Fiberglass	7.650	0.00	0.00
(local) 0.306	4.300	0.00	0.00
(local) 0.36in Fiberglass	4.900	0.00	0.00
(local) 1" Aluminum Pipe	0.007	0.00	0.00
(local) 1-1/2in STD Steel Pipe	0.038	0.00	0.00
(local) Tempered Glass	1.300	0.00	0.00

Material Library - Solid Materials

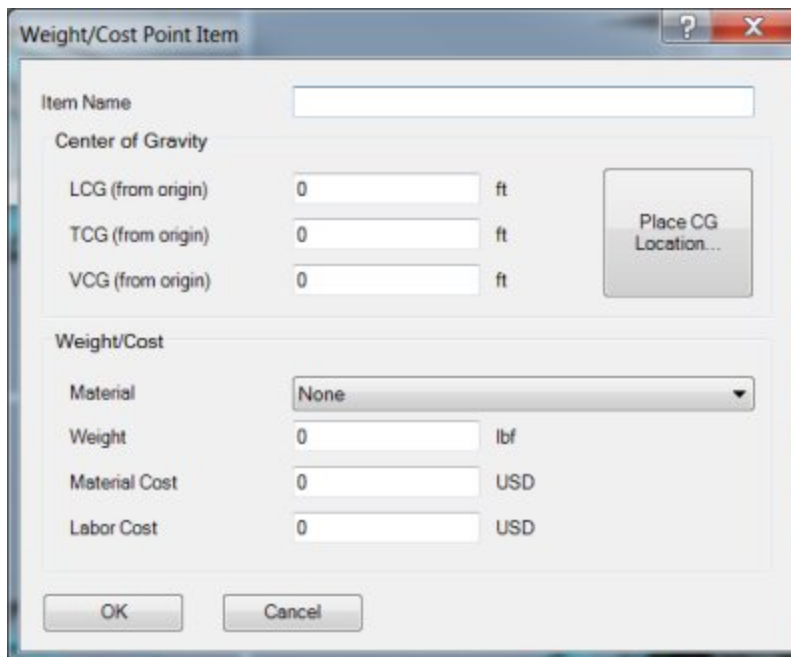
Material Name	Mass/Volume (lbm/ft^3)	Material Cost/Volume (USD/ft^3)	Labor Cost/Volume (USD/ft^3)
(local) Unleaded Gasoline	45.430	35.00	0.00

Ready

14.7 Weight/Cost Point Item

Toolbar	
Menu	Orca3D > Weight/Cost > Create Weight/Cost Point
Command	OrcaCreateWeightCostPoint

A point weight item can be quickly entered into your model using the OrcaCreateWeightCostPoint command. This command will create a point object in your model, either with a specific weight and cost or a weight/cost material assigned to it.



The dialog box is titled "Weight/Cost Point Item". It contains the following fields and controls:

- Item Name:** A text input field.
- Center of Gravity:**
 - LCG (from origin):** A text input field with "0" and a unit of "ft".
 - TCG (from origin):** A text input field with "0" and a unit of "ft".
 - VCG (from origin):** A text input field with "0" and a unit of "ft".
 - Place CG Location...:** A button to the right of the CG input fields.
- Weight/Cost:**
 - Material:** A dropdown menu currently showing "None".
 - Weight:** A text input field with "0" and a unit of "lbf".
 - Material Cost:** A text input field with "0" and a unit of "USD".
 - Labor Cost:** A text input field with "0" and a unit of "USD".
- Buttons:** "OK" and "Cancel" buttons at the bottom.

Enter an Item Name, then either enter the LCG, TCG, and VCG, or select "Place CG location" and select the CG graphically. Next, either select a Material (from the [Stock Material Library](#)⁴⁶⁶), or enter a Weight, Material Cost, and Labor Cost.

Part

XV

15 Grasshopper Components

Grasshopper components have been developed for Hydrostatics & Stability calculations. Please see the [Grasshopper Components for Hydrostatics](#) ³⁰⁹ section for more information.

Part



16 Frequently Asked Questions

This section covers some problems that are frequently encountered by users of Orca3D. The questions are organized by category and where necessary links are provided to relevant sections of the help.

16.1 General Questions

- [What are the requirements to run Orca3D?](#) ⁴⁸⁷
- [Why is Rhino required?](#) ⁴⁸⁷
- [Where can I get help with questions or problems?](#) ⁴⁸⁸



What are the requirements to run Orca3D?

Orca3D is a plug-in for Rhino. You must have Rhino installed prior to installing Orca3D. If you do not, please download Rhino from the Rhino web site and install it before installing Orca3D.

Note:

Specific requirements:

- Rhino Version 6, SR 6 or higher.
- Hardware: See Rhino hardware requirements (https://www.rhino3d.com/6/system_requirements)
- Operating Systems tested: Windows 10
- Operating Systems not tested: Windows 7, 8, 8.1
- Operating Systems not supported: Windows ME, 98, 95, NT, XP
- Mac: The Intel Mac with Bootcamp or Parallels has not been tested (Bootcamp may work)
- VMWare: Licensing Orca3D under VMWare and similar virtual environments is **not supported** (note that the Orca3D floating network server can be licensed in a VMWare environment)
- Microsoft .NET Framework 3.5 SP1 (the Orca3D installation will attempt to install it if it is not already on your computer)
- Microsoft Report Viewer Redistributable 2010 (the Orca3D installation will attempt to install it if it is not already on your computer)
- Microsoft Visual C++ 2005 Runtime Libraries (the Orca3D installation will attempt to install it if it is not already on your computer)
- Valid license key (without this, Orca3D will operate as a 15-day fully functional evaluation copy)



Why is Rhino required?

Orca3D is written as a plug-in to Rhino, to complement Rhino's already exceptional modeling capabilities. This gives the user the best of both worlds; a powerful, easy-to-use, and well-known CAD system, enhanced with marine-specific functions.



Where can I get help with questions or problems?

There are a number of resources for assistance; please see our website for details. If you cannot find an answer to your question there, please send an email to support@orca3d.com.

» [Return to Top](#) ^[488]«

16.2 Licensing Questions

- [My trial period has ended. How do I get a license?](#) ^[488]
- [Why won't some of the Orca3D functions work on my computer?](#) ^[488]
- [I want to move my copy of Orca3D to another computer. How do I transfer the license?](#) ^[489]
- [My computer has crashed, was lost/stolen, or I no longer have access to it. How do I transfer the license to a new computer?](#) ^[489]
- [Can Orca3D use the Rhino workgroup license manager called "The Zoo" for floating network licensing?](#) ^[489]



My trial period has ended. How do I get a license?

The trial period is a 15-day, fully-functional evaluation license. If you're ready to purchase, please visit our [Order](#) web page. If you feel that you need more time to evaluate the software before purchasing, please follow these steps:

1. Start Rhino and run the command OrcaLicense.
2. Send the License Key that is shown to support@orca3d.com, with a note requesting an extension of your evaluation period. We will update your license to extend your trial period and notify you. In the meantime, you may continue to use Rhino.



Why won't some of the Orca3D functions work on my computer?

Orca3D is licensed by module; you will not be able to run a function that belongs to a module that you have not purchased. If you would like to purchase another module, please visit our [Order](#) web page.

***I want to move my copy of Orca3D to another computer. How do I transfer the license?***

You may install Orca3D on the other computer using the License Key that you were provided when you purchased the software. Be sure to uninstall Orca3D on the original computer; if both computers are detected using the license, the license will be deactivated and Orca3D will not function on either computer. Please contact us at support@orca3d.com if this happens to you.

***My computer has crashed, was lost/stolen, or I no longer have access to it. How do I transfer the license to a new computer?***



Simply install Orca3D on your new computer, using your License Key. This will be allowed, as long as it does not happen often.

***Can Orca3D use the Rhino workgroup license manager called "The Zoo" for floating network licensing?***

Currently, the Rhino licensing mechanism is not exposed to third party plug-in developers in the Rhino SDK. Therefore, Orca3D has its own software licensing scheme that is completely separate from Rhino's. You can use Orca3D on a computer that is using The Zoo for its Rhino license. However, you must have the Orca3D license on that computer as well. We offer our own network licensing solution; please contact us for details.

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16.3 Hull Design & Fairing

- [When I edit control points, why don't the sections update?](#) 
- [In the Hull Assistant, why do some input values create crazy shapes?](#) 

***When I edit control points, why don't the sections update?***

The sections will not update unless you use Orca3D's custom control points. Turning the standard Rhino control points on and editing will change the shape of the surface, but you'll need to update the sections manually, using the Orca3D Sections command.



In the Hull Assistant, why do some input values create crazy shapes?

The equations that are used to generate the 3D hull shapes degenerate with certain conditions, such as various values being set to 0.

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16.4 Hydrostatics & Stability

[I get an error when I try to run hydrostatics. Why can't I get results?](#) ⁴⁹⁰

[Why is the displacement value too low?](#) ⁴⁹¹

[Why is the displacement value negative?](#) ⁴⁹²

[Why aren't the Cp \(prismatic coefficient\) and Cx \(maximum section coefficient\) reported?](#) ⁴⁹²

[Why is there a spike in the sectional area curve?](#) ⁴⁹³



I get an error when I try to run hydrostatics. Why can't I get results?

This usually results from Orca3D not being able to find an equilibrium. Often the cause is a surface edge becoming submerged, such as the deck edge when the vessel heels. If this is the case, add a deck (or other surface) to your model to seal it. If you do not expect an open edge to become submerged, you should check your VCG to be sure that it is correct.



Why is the displacement value too low?

Possible reasons for this include:

- If you have modeled only half of the hull, but not checked the "Mirror About the Centerplane" box, your values will be half of what they should be.
- Orca3D computes most of the hydrostatic data from a surface mesh, not with the traditional approach of integrating stations. The user has control over the density of this mesh, just as you do with Rhino's display or analysis mesh. If the mesh is too coarse, your values will be low. If they are too high, it will slow down the computations without adding appreciable accuracy. The settings may be adjusted using the OrcaProperties command. You should experiment with different settings, and see their effect on your results. As you increase the density of the mesh, you will reach a point of diminishing returns.
- Surfaces in Rhino have the concept of an "inside" and an "outside." The outside should be the side in contact with the water; if not, the volume of that surface will be computed to be negative. If your model consists of multiple surfaces (not joined), and some of them have the outside direction incorrect, they will deduct from the total. There are two ways to visualize the outside direction of a surface; first, you can select the Direction command from Rhino's Analyze menu. Arrows will be drawn in the outward direction, and so should point into the water (note that for surfaces such as bow thruster tunnels, this means that the arrows will be pointing into the interior of the cylinder). If you find a surface whose direction is incorrect, use the Flip option in the Direction command to flip it to the correct direction. If you have many surfaces, this can become tedious; a more effective way to quickly see the directions of the surfaces is to use Rhino's Backface Settings. Select the Perspective viewport, and change to a shaded rendering. Right-click on the viewport title (Perspective), and select Display Options from the menu. Go to Rhino Options/Appearance/Advanced Settings/Shaded, and select Shaded. For the Backface Settings option, select "Single Color for all backfaces," and then select a color that stands out in your model. Now, as you rotate the model, you can quickly visualize the backface (inside) of each of your surfaces. You can now use the Flip command to flip the direction of any surfaces that are incorrect.



Why is the displacement value negative?

Surfaces in Rhino have the concept of an "inside" and an "outside." The outside should be the side in contact with the water; if not, the volume of that surface will be computed to be negative. If your model consists of multiple surfaces (not joined), and some of them have the outside direction incorrect, they will deduct from the total. There are two ways to visualize the outside direction of a surface; first, you can select the Direction command from Rhino's Analyze menu. Arrows will be drawn in the outward direction, and so should point into the water (note that for surfaces such as bow thruster tunnels, this means that the arrows will be pointing into the interior of the cylinder). If you find a surface whose direction is incorrect, use the Flip option in the Direction command to flip it to the correct direction. If you have many surfaces, this can become tedious; a more effective way to quickly see the directions of the surfaces is to use Rhino's Backface Settings. Select the Perspective viewport, and change to a shaded rendering. Right-click on the viewport title (Perspective), and select Display Options from the menu. Go to Rhino Options/Appearance/Advanced Settings/Shaded, and select Shaded. For the Backface Settings option, select "Single Color for all backfaces," and then select a color that stands out in your model. Now, as you rotate the model, you can quickly visualize the backface (inside) of each of your surfaces. You can now use the Flip command to flip the direction of any surfaces that are incorrect.



Why aren't the Cp (prismatic coefficient) and Cx (maximum section coefficient) reported?

Although Orca3D uses a mesh to compute most of the hydrostatics, certain quantities can only be computed from stations. These include the prismatic and maximum section coefficients, and of course the sectional area curve. Orca3D uses the stations that are defined in the OrcaSection command to compute these quantities. In order to get accurate values, you should be careful to use a reasonable number and distribution of stations. The ends of the hull, and any areas of distinct section change should be captured in order to get an accurate sectional area curve, and you should have stations near the station of maximum sectional area in order to get an accurate Cp and Cx (note that you don't need to find it exactly; Orca3D will interpolate, using a quadratic function over three stations, to find the maximum).



Why is there a spike in the sectional area curve?

- If you have two surfaces joined in a station plane that coincides exactly with one of the station locations that you have defined, Orca3D will compute stations on both surfaces, so the sectional area there will be double what it should be. One case where this can happen is with a hull that has a planar, vertical transom, and the transom surface is modeled. Simply move the station location slightly forward or aft, so it doesn't coincide with the joint between the two surfaces.
- Incorrect sectional area data can also result from including non-wetted surfaces in your selection when you compute hydrostatics. For example, if you have modeled interior surfaces, and include them in the calculations, Orca3D will include their areas in the sectional area curve (as well as their volumes, so your displacement, and all of the other hydrostatics values will be incorrect).
- If you have a loose absolute tolerance setting, equal to or greater than your section spacing, Orca3D will not be able to distinguish successive stations from one another, resulting in incorrect values.
- Check to be sure that you have correctly specified whether to "Mirror About the Centerplane" when setting up your hydrostatics calculation. If you have modeled the entire hull (port and starboard halves), and you check the "Mirror About the Centerplane" box, your sectional area values (and displacement) will be double the correct values.

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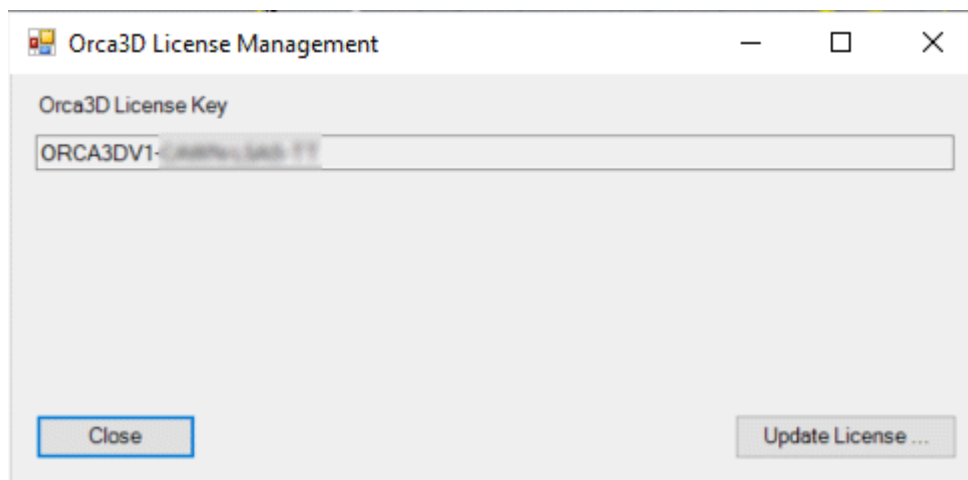
Part



17 Licensing

The CopyMinder licensing system is straightforward to activate, non-intrusive, and reliable. Importantly, it will automatically handle situations where you need to move the software to a new computer or re-install after a hardware failure, without the need to contact us or for you to go to a website to de-activate your old license. This capability is possible because the system accesses the CopyMinder server over the Internet every so often. Some time before Orca3D is **required** to contact the CopyMinder server, the system **tries** to connect to the server (a so-called “pre-check”); if it is successful it resets the time until the next required contact; if it is unable to, it will notify you that you must be connected to the Internet within a specific amount of time so that it can validate the license again.

You can use the OrcaLicense command to find your License Key, and to force Orca3D to contact the CopyMinder server. For example, if you upgrade your Orca3D license from one level to the next, we make the change to your License Key on the CopyMinder server. This update won't be reflected on your computer until you connect to the CopyMinder server.



Update Orca3D License?



Updating the Orca3D license requires Internet access and may change the state of your current license. Are you sure you wish to continue with the license update?

If you click Yes, another dialog requesting permission to access the Internet might pop up behind the Rhino window. If that dialog does open, the license update process will not continue until you've selected that window and clicked the button to continue.

Yes

No

Cancel

ORCA3DV1



If you have an Internet connection, this program will try to connect to the internet to automatically check that it is a valid installation.

Please click 'Ok' to proceed or 'Cancel' to not access the Internet.

☐ Don't show this message again

OK

Cancel

Privacy Policy

License Updated!



Orca3D License Update was successful. Use Orca3D > Help > About Orca3D to check license status.

OK

Part

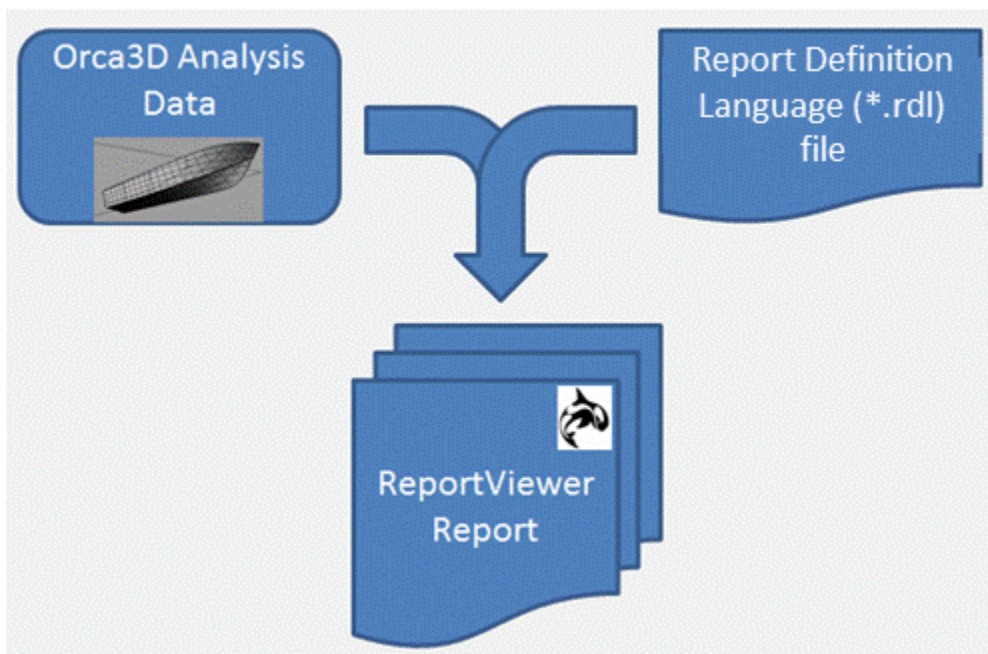


18 Custom Report Design

The reports that are generated in Orca3D, such as the Hydrostatics & Stability report, the Weight & Cost report, and others make use of a technology known as Microsoft Reporting Services. This technology separates the process of designing a report from that of generating and populating a report with actual data. The report is designed in a tool such as Microsoft Report Designer or Microsoft Report Builder and is generated and displayed using Microsoft Report Viewer. For the Orca3D end user this means that custom reports can be designed to meet specific needs.

The report design is stored in a file format known as a Report Definition Language (*.rdl). This is an XML file that defines the specific structure and contents of the resulting report. The Orca3D installation includes several standard .rdl files for each of the report types. These files can be customized to your liking using a free tool available from Microsoft known as Microsoft SQL Server Report Builder.

While there is certainly a learning curve involved in creating a new report, making minor changes to the standard format files is reasonably straightforward. If you need a report format that is significantly different from the standard formats, and you don't want to take on the task of learning to use the Report Builder, contact us about report format design services.

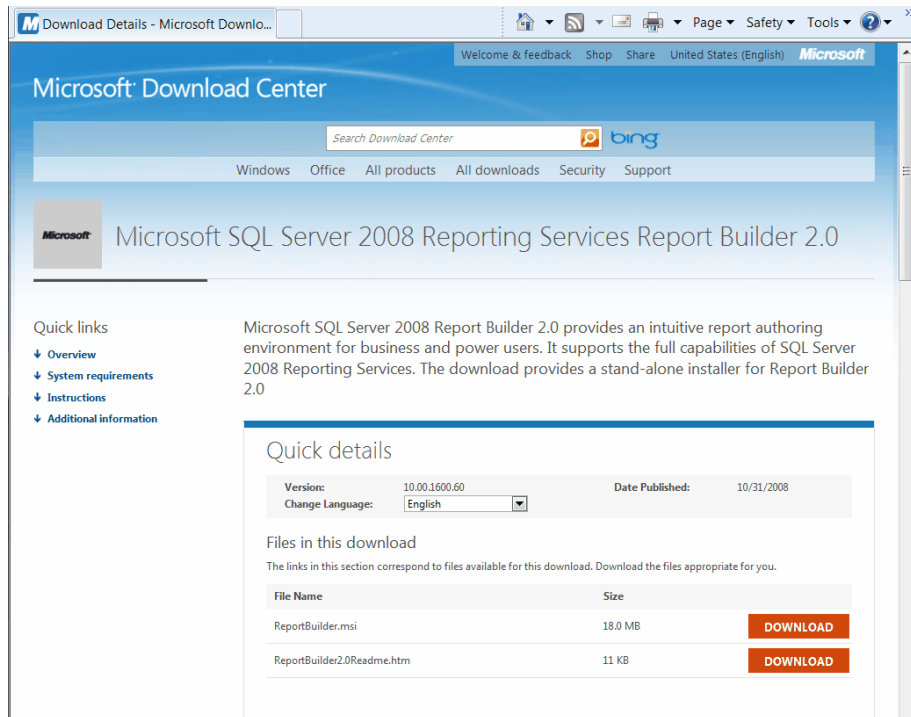


18.1 Installing the Report Builder

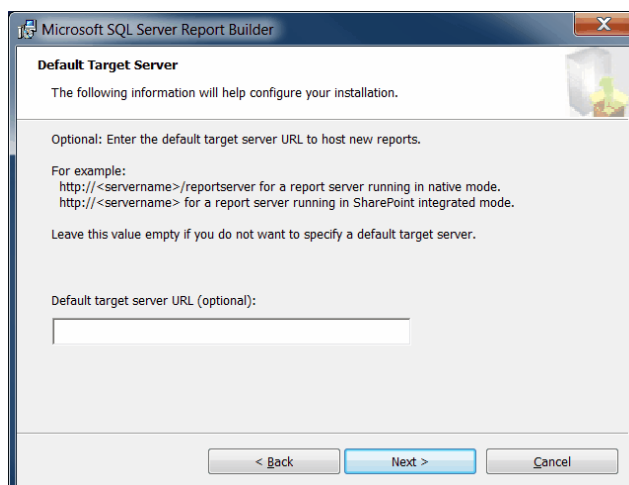
The first step towards creating your own report formats is to download and install the Microsoft SQL Server Report Builder Version 2.0.

IMPORTANT: To be compatible with Orca3D, you must use Version 2.0. Later versions of Report Builder will NOT work.

The installation file (*ReportBuilder.msi*) can be downloaded from Microsoft here: <http://www.microsoft.com/download/en/details.aspx?displaylang=en&id=24085>



Once you have downloaded this file to your computer, double-click it to run it. During installation, you will be prompted for a Default Target Server, as seen below. Simply leave it blank, and click on Next.

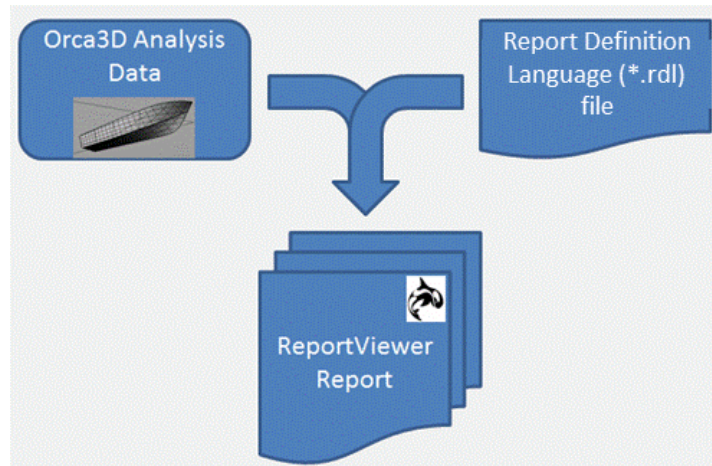


Once the installation is complete, you can run Report Builder from your Start menu.

Before beginning to create or edit any report format files, please read the sections [Understanding the Report Structure](#)^[500], and [Using a Custom Report](#)^[507].

18.2 Understanding the Report Structure

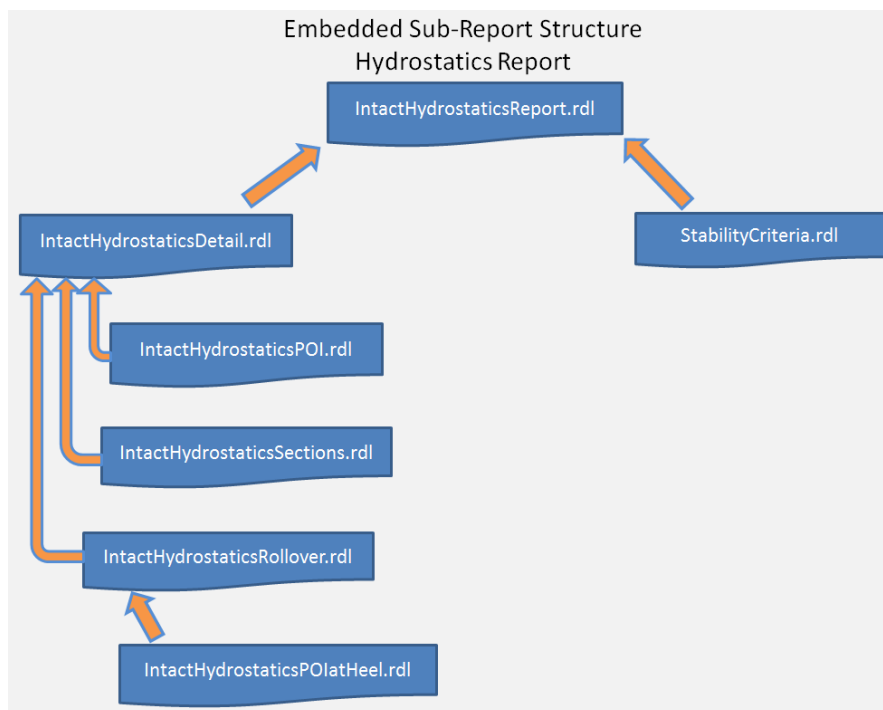
Reports (Hydrostatics, Weight/Cost, Resistance Analysis, etc.) are a combination of the analysis data from Orca3D, and a Report Definition Language file (*.rdl):



Sub-Reports

Orca3D's default reports all use a feature of Microsoft Reporting Services called "sub-reports." A subreport is a report item that displays another report inside the body of a main report. Conceptually, a subreport in a report is similar to a frame in a Web page. It is used to embed a report within a report. Any report can be used as a subreport. The report that is displayed as the subreport is stored in the same folder as the parent report. You can design the parent report to pass parameters to the subreport. For example, the Hydrostatics & Stability report has a "Detail" section for each condition that you have analyzed (e.g., each draft in a range of drafts). This is done by repeating a sub-report within the main report, one time for each condition. So, *IntactHydrostaticsDetail.rdl* is embedded within *IntactHydrostaticsReport.rdl*.

It is also possible to have multiple layers of nesting. If you study the *IntactHydrostaticsDetail.rdl* file, you'll see that it, in turn, contains three embedded reports; *IntactHydrostaticsPOI.rdl*, *IntactHydrostaticsSections.rdl*, and *IntactHydrostaticsRollover.rdl*.



Recommended Approach

Because parent reports reference subreports by name, it is imperative that you not change a subreport's name without changing the referenced name in the parent report. To avoid potential confusion and mistakes when customizing Orca3D reports, we suggest that you begin by creating a new folder (perhaps named for your project), and then copy all of the default files into that folder. Make the desired changes to the *rdl* files, but do not change their names. This way you can be sure that they are all properly referenced from the other reports.

The *rdl* files that match the default reports are located in the DRSC3ATC\Orca3D subfolder, in the "CommonApplicationData" folder (on XP, this is C:\Documents and Settings\All Users\Application Data, and in Windows 7, it's C:\ProgramData).

For example, if you wanted to have your own custom reports, as well as different custom reports for your customers Alpha Yachts and Beta Yachts, you could create the subfolders as follows, and start by copying each of the default *rdl* files into these folders:

Windows Vista and Windows 7:

```

c:\ProgramData\DRSC3ATC\Orca3D\MyReports
c:\ProgramData\DRSC3ATC\Orca3D\AlphaYachts
c:\ProgramData\DRSC3ATC\Orca3D\BetaYachts
  
```

Windows XP:

```

C:\Documents and Settings\All Users\Application Data\DRSC3ATC\Orca3D\MyReports
  
```

C:\Documents and Settings\All Users\Application Data\DRSC3ATC\Orca3D\AlphaYachts

C:\Documents and Settings\All Users\Application Data\DRSC3ATC\Orca3D\BetaYachts

18.3 Creating a Custom Report

This documentation is not intended to cover the details of how to design rdl reports using Microsoft SQL Server Report Builder; that program has its own Help file. But there are some important issues to be aware of before getting started.

Recommended Approach

As stated previously, because parent reports reference subreports by name, it is imperative that you not change a subreport's name without changing the referenced name in the parent report. To avoid potential confusion and mistakes when customizing Orca3D reports, we suggest that you begin by creating a new folder (perhaps named for your project), and then copy all of the default files into that folder. Make the desired changes to the *rdl* files, but do not change their names. This way you can be sure that they are all properly referenced from the other reports.

The *rdl* files that match the default reports are located in the DRSC3ATC\Orca3D subfolder, in the "CommonApplicationData" folder (on XP, this is C:\Documents and Settings\All Users\Application Data, and in Windows 7, it's C:\ProgramData).

For example, if you wanted to have your own custom reports, as well as different custom reports for your customers Alpha Yachts and Beta Yachts, you could create the subfolders as follows, and start by copying each of the default *rdl* files into these folders:

Windows Vista and Windows 7:

c:\ProgramData\DRSC3ATC\Orca3D\MyReports

c:\ProgramData\DRSC3ATC\Orca3D\AlphaYachts

c:\ProgramData\DRSC3ATC\Orca3D\BetaYachts

Windows XP:

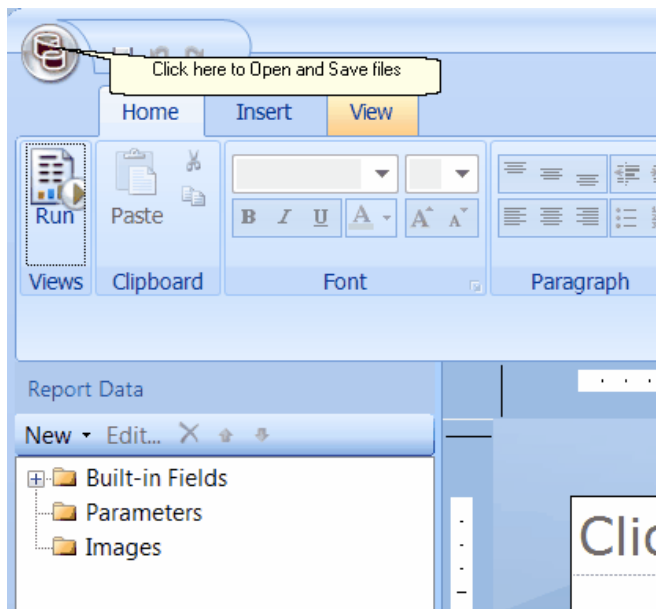
C:\Documents and Settings\All Users\Application Data\DRSC3ATC\Orca3D\MyReports

C:\Documents and Settings\All Users\Application Data\DRSC3ATC\Orca3D\AlphaYachts

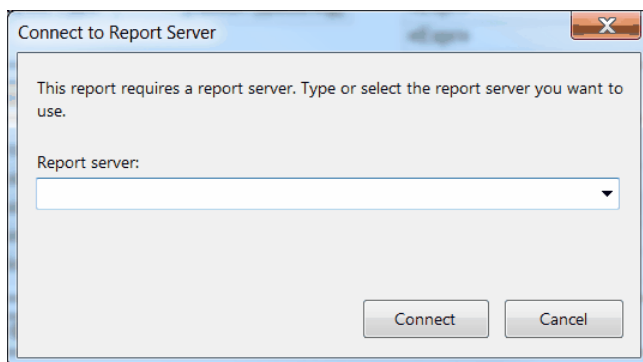
C:\Documents and Settings\All Users\Application Data\DRSC3ATC\Orca3D\BetaYachts

Opening an rdl File

To open one of the default rdl report files, start Report Builder, and click on the icon in the upper-left corner of the screen:



When you open an rdl file, you will be asked to connect to a Report Server. Leave it blank, and click on Cancel.



Now you are ready to begin editing. As an example, we'll edit the Hydrostatics Report to add the ratio of LOA to Depth Overall to the detail page of the report, and change the yellow color in the section title boxes to blue. Here are the steps:

1. Load the file IntactHydrostaticsDetail.rdl (remember that you should be working on a copy of this file, in a new folder that you've created)
2. When you are prompted to enter the Report Server, click Cancel.
3. Scroll down to the section in the report entitled "Overall Dimensions."
4. From Report Builder's Insert menu, select Text Box
5. Draw a box as shown in the figure below, and enter the text LoA / D. Be sure that the box does not overlap the box above it, or the frame below it. Once it's drawn, you can move it and resize it as necessary.

Overall Dimensions				
Length Overall, LOA	[Loa]	[LengthUnit]	Loa / Boa	«Expr»
Beam Overall, Boa	[Boa]	[LengthUnit]	Boa / D	«Expr»
Depth Overall, D	[Depth]	[LengthUnit]	Loa / D	

Draw the box here, and enter the text Loa / D

6. Insert another box to the right, which will hold the value. Make sure the cursor is NOT in the box, and then right-click on the box, and select Expression from the menu.

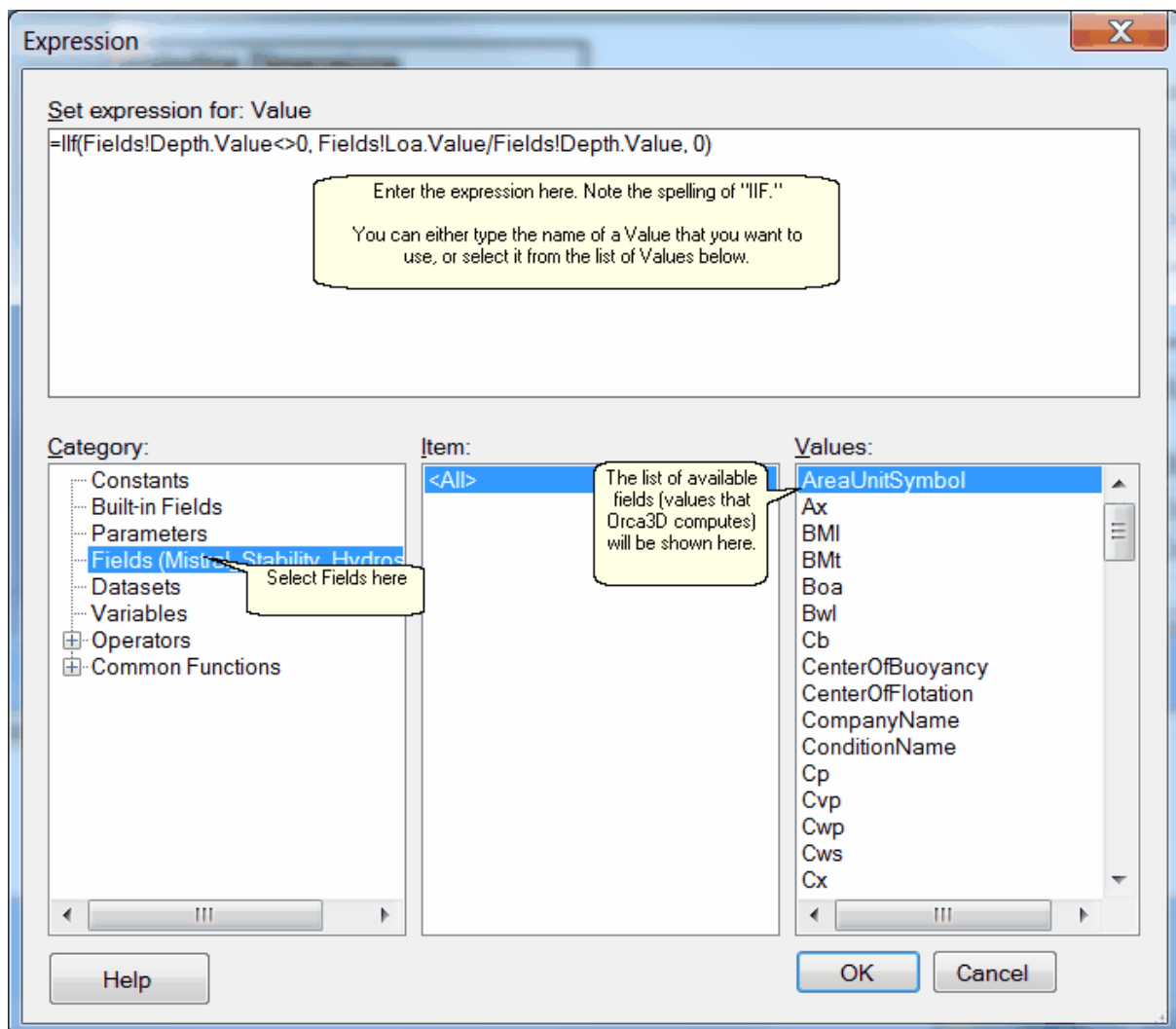
Loa / Boa	«Expr»
Boa / D	«Expr»
Loa / D	

Lwl / Bwl	«Expr»
Bwl / T	«Expr»
D / T	«Expr»

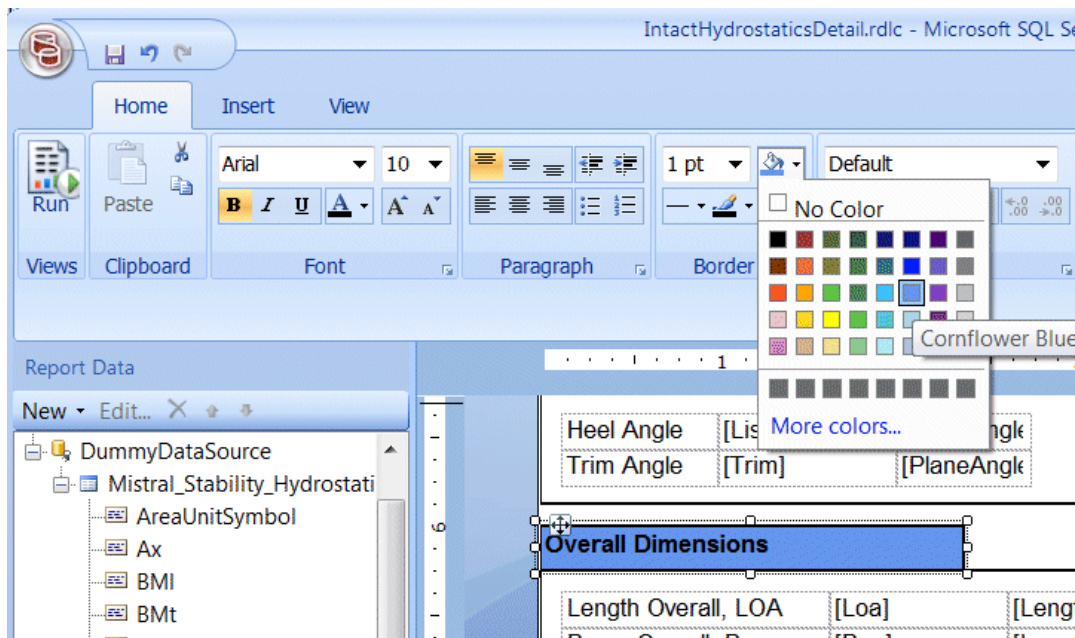
7. In the Expression dialog, click on Fields under Category. All of the available fields to be used in the expression will be shown under Values. You may type in the expression in the dialog, and/or click on these fields to add them to your expression. Enter the expression:

=IIf(Fields!Depth.Value<>0, Fields!Loa.Value/Fields!Depth.Value, 0)

Note that we have first checked to be sure that the value of Depth is not 0, so that we don't get an error when the report is generated. The "if" operator in ReportBuilder is spelled "IIF." You'll notice that this syntax is similar to that used in Excel. See more detail on [Expressions](#) below.



8. Now, to change the color of the section header box from yellow to blue, click on the box (e.g., "Overall Dimensions"), and in Report Builder's Home menu, select the Fill color that you'd like:

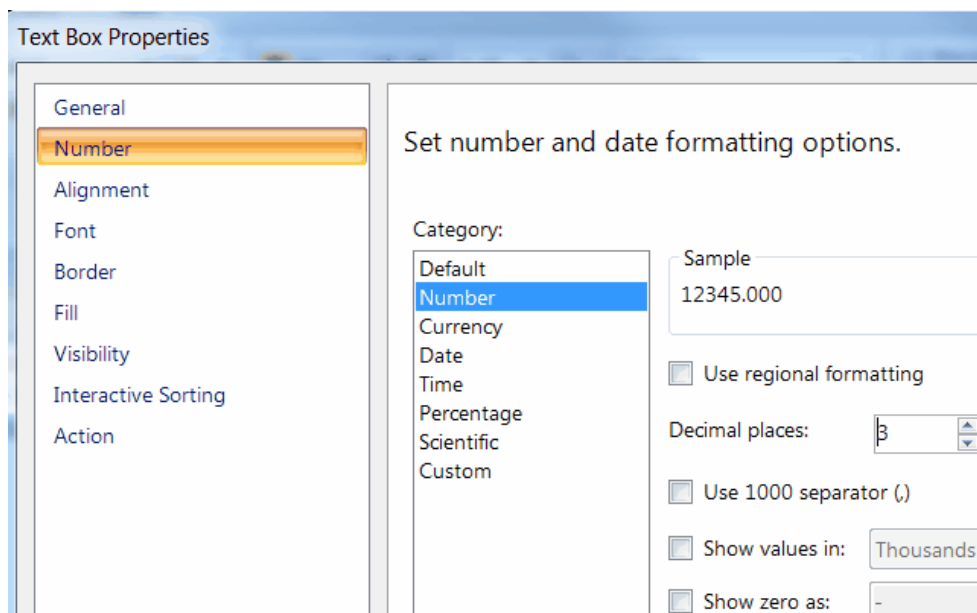


9. Save the file.

Now, you need to tell Orca3D to use this file. In Orca Properties, select the Report tab, and click the box next to Hydrostatics. Then use the Browse button (...) to select the default file (IntactHydrostaticsReport.rdl). Remember that the file you just modified is embedded in that report, so you do not select that file. See [Using a Custom Report](#)^[507] for more details.

Overall Dimensions			
Length Overall, LOA	10.000 m	Loa / Boa	3.636
Beam Overall, Boa	2.750 m	Boa / D	2.115
Depth Overall, D	1.300 m	Loa / D	7.692307621769
			65

When you go to the detail page of the report, you can see the result of your changes. We probably don't want that value to display so many digits after the decimal, so go back to Report Builder, right-click on the expression and select Text Box Properties. Then, select Number; under Category, select Number, and adjust the number of decimal places as desired (again, this is similar to working with Excel):



Of course you're not limited to making this type of minor change. Please study the Report Builder 2.0 Help guide for further information on creating and editing reports.

Expressions

Expressions are widely used throughout a report to retrieve, calculate, display, group, sort, filter, parameterize, and format data. Many report item properties can be set to an expression. Expressions help you control the content, design, and interactivity of your report. Expressions are written in Microsoft Visual Basic, saved in the report definition, and evaluated by the report processor when you run the report.

Unlike applications such as Microsoft Office Excel where you work with data directly in a worksheet, in a report, you work with expressions that are placeholders for data. To see the actual data from the evaluated expressions, you must run the report. When you run the report, the report processor evaluates each expression as it combines report data and report layout elements such as tables and charts.

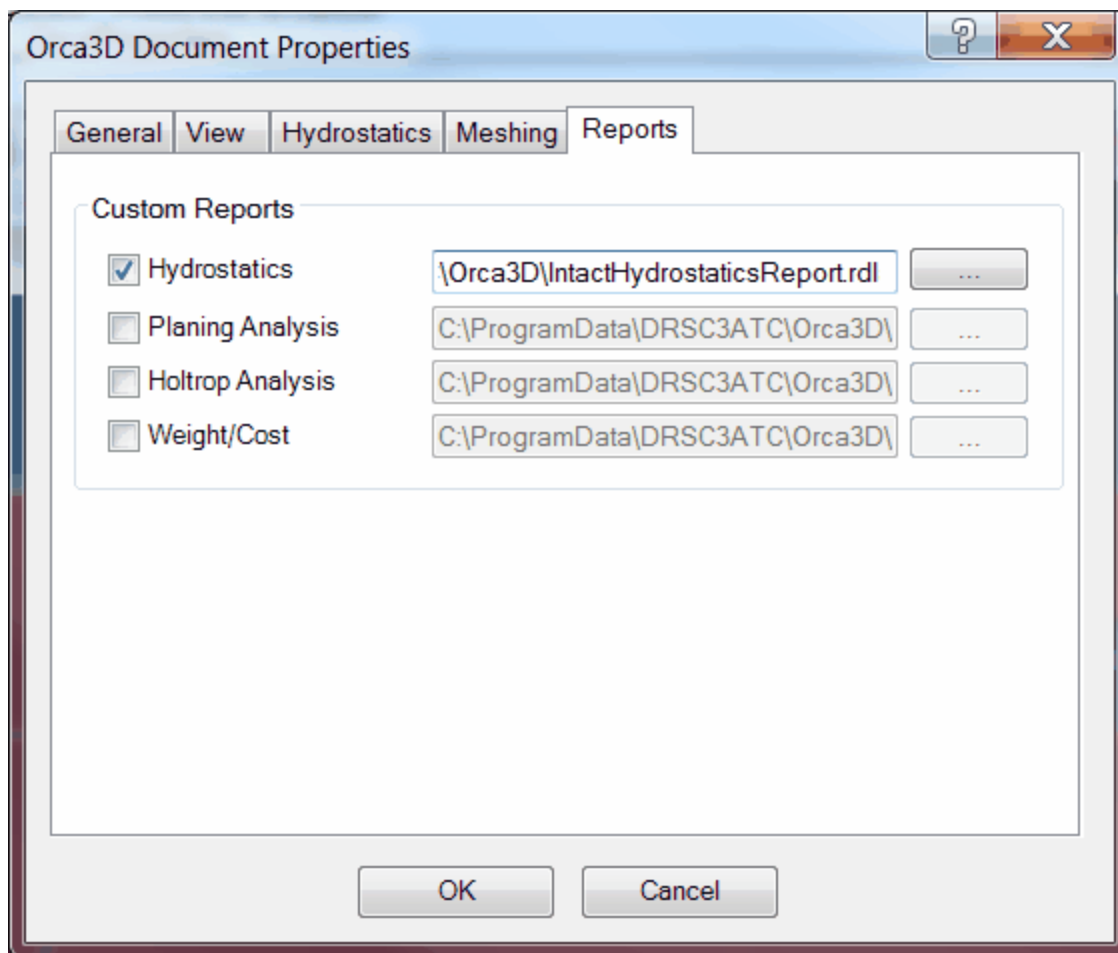
As you design a report, many expressions for report items are set for you. For example, when you drag a field from the Report Data pane to a table cell on the report design surface, the text box value is set to a simple expression for the field. For example, the cell that displays the "Displacement" value in the IntactHydrostaticsDetail.rdl is shown as [Displacement]; more complex expressions are simply shown as <<Expr>>, and you must right-click and select Expression to see the details.

18.4 Using a Custom Report

Once you have created a custom format file, you need to tell Orca3D to use it. In Orca Properties, in the Reports tab, there are two steps; first, by checking the box next to the report type, you instruct Orca3D NOT to use the built-in default format. The second step is to

specify the path to the *rdl* file that you have created.

If you edit one of the sub-reports, you still need to tell Orca3D not to use the built-in format. Check the Custom Report box next to the appropriate report, and browse to the main report (e.g., *IntactHydrostaticsReport.rdl*) in the folder where you have made changes to the sub-report.



Note that Orca3D has the default formats built-in, so there is no risk that you might accidentally change the defaults. In other words, when the check boxes above are blank, Orca3D creates the reports using format information that is built-in to the application, not from an *rdl* file. The *rdl* files that are distributed with Orca3D are identical to the built-in formats; *however, it's a good idea to make copies of the rdl files that are distributed, before making any changes.*

Part



19 Verification and Testing

The following manual provides Orca3D hydrostatic and stability results for several primitive shapes with varying mesh densities and drafts. The values are compared to known, analytic calculations to verify the accuracy of Orca3D's calculations. The shapes used are a cube, a sphere, a horizontally oriented cylinder, a cone, and a vertically orientated cylinder.

The cube's simple shape and flat surfaces allows Orca3D to accurately calculate hydrostatic and stability properties at lower mesh densities

Hydrostatic and stability calculations using the sphere, vertical cylinder, cone, and horizontal cylinder are accurate within 1% error for mesh densities between 0.5 and 1.0. There is a noticeable accuracy improvement for the sphere calculations between mesh densities of 0.6 and 0.7, whereas noticeable differences in accuracy for the vertical cylinder, cone, and horizontal cylinder occur between mesh densities of 0.7 and 0.8. These accuracy differences are documented in the tables below and in graphical form in the mesh density accuracies section.

These same primitive shapes were also tested for free float conditions. Each shape was given three input weights and the results were compared to analytic calculations.

Righting arm curves were verified for the sphere and the horizontal cylinder. As expected, the righting arm remained zero when the VCG of each object was at its centroid and followed a sine curve when it was placed elsewhere.

19.1 Primitive Shapes and Mesh Densities

The following presents the results for the primitive shapes at mesh densities between 0.5 and 1.0. The shapes were also compared to analytic results for sinkage levels of +/- 1.0 meter at a mesh density of 0.7.

2.1 Cube Results

The cube is 10 meters in length with its vertical center on the horizontal construction plane.

5 m draft	Water Density 1025.9 kg/m ³		0.5 Mesh Density		% Error	0.6 Mesh Density		% Error	0.7 Mesh Density		% Error
	Analytic		Orca3D			Orca3D			Orca3D		
Displaced Volume	500.000	m ³	500	m ³	0.000	500	m ³	0.000	500	m ³	0.000
VCB	-2.500	m	-2.500	m	0.000	-2.500	m	0.000	-2.500	m	0.000
Area Moment of Inertia	833.330	m ⁴	833.3	m ⁴	0.000	833.3	m ⁴	0.000	833.3	m ⁴	0.000
Waterplane Area	100.000	m ²	100.00	m ²	0.000	100.00	m ²	0.000	100.00	m ²	0.000
Immersed Area	50.000	m ²	50.0	m ²	0.000	50.0	m ²	0.000	50.0	m ²	0.000
Wetted Surface	300.000	m ²	300.00	m ²	0.000	300.00	m ²	0.000	300.00	m ²	0.000
Wetted Girth	20.000	m	20.00	m	0.000	20.00	m	0.000	20.00	m	0.000
BM	1.667	m	1.667	m	0.020	1.667	m	0.020	1.667	m	0.020

Table 2.1.1 Cube Mesh Density 0.5-0.7 Results

5 m draft	Water Density 1025.9 kg/m ³		0.8 Mesh Density		% Error	0.9 Mesh Density		% Error	1.0 Mesh Density		% Error
	Analytic		Orca3D			Orca3D			Orca3D		
Displaced Volume	500.000	m ³	500	m ³	0.000	500	m ³	0.000	500	m ³	0.000
VCB	-2.500	m	-2.500	m	0.000	-2.500	m	0.000	-2.500	m	0.000
Area Moment of Inertia	833.330	m ⁴	833.3	m ⁴	0.000	833.3	m ⁴	0.000	833.3	m ⁴	0.000
Waterplane Area	100.000	m ²	100.00	m ²	0.000	100.00	m ²	0.000	100.00	m ²	0.000
Immersed Area	50.000	m ²	50.0	m ²	0.000	50.0	m ²	0.000	50.0	m ²	0.000
Wetted Surface	300.000	m ²	300.00	m ²	0.000	300.00	m ²	0.000	300.00	m ²	0.000
Wetted Girth	20.000	m	20.00	m	0.000	20.00	m	0.000	20.00	m	0.000
BM	1.667	m	1.667	m	0.020	1.667	m	0.020	1.667	m	0.020

Table 2.1.2 Cube Mesh Density 0.8-1.0 Results

Model Sinkage = -1.0m	Water Density 1025.9 kg/m ³		Mesh Density 0.7		% Error
	Analytic		Orca3D		
Displaced Volume	400.000	m ³	400	m ³	0.000
VCB	-3.000	m	-3.000	m	0.000
Area Moment of Inertia	833.333	m ⁴	833.3	m ⁴	0.004
Waterplane Area	100.000	m ²	100.00	m ²	0.000
Immersed Area	40.000	m ²	40.0	m ²	0.000
Wetted Surface	260.000	m ²	260.00	m ²	0.000
Wetted Girth	18.000	m	18.00	m	0.000
BM	2.083	m	2.083	m	0.016

Table 2.1.3 Cube Negative Sinkage Results

Model Sinkage = 1.0m	Water Density 1025.9 kg/m ³		Mesh Density 0.7		% Error
	Analytic		Orca3D		

Displaced Volume	600.00 0	m ³	600	m ³	0.00 0
VCB	-2.000	m	-2.000	m	0.00 0
Area Moment of Inertia	833.33 3	m ⁴	833.3	m ⁴	0.00 4
Waterplane Area	100.00 0	m ²	100.00	m ²	0.00 0
Immersed Area	60.000	m ²	60.0	m ²	0.00 0
Wetted Surface	340.00 0	m ²	340.00	m ²	0.00 0
Wetted Girth	22.000	m	22.00	m	0.00 0
BM	1.389	m	1.389	m	0.00 8

Table 2.1.4 Cube Positive Sinkage Results

2.2 Sphere Results

The sphere is 10 meters in diameter with its center on the horizontal construction plane.

5 m draft	Water Density 1025.9 kg/m ³		0.5 Mesh Density		% Error	0.6 Mesh Density		% Error	0.7 Mesh Density		% Error
	Analytic		Orca3D			Orca3D			Orca3D		
Displaced Volume	261.799	m ³	260.7	m ³	0.420	260.7	m ³	0.420	261.5	m ³	0.114
VCB	-1.875	m	-1.874	m	0.053	-1.874	m	0.053	-1.875	m	0.000
Area Moment of Inertia	490.874	m ⁴	489.3	m ⁴	0.321	489.3	m ⁴	0.321	490.5	m ⁴	0.076
Waterplane Area	78.540	m ²	78.41	m ²	0.165	78.41	m ²	0.165	78.51	m ²	0.038
Immersed Area	39.270	m ²	39.3	m ²	0.077	39.3	m ²	0.077	39.3	m ²	0.077
Wetted Surface	157.080	m ²	156.76	m ²	0.203	156.76	m ²	0.203	157.00	m ²	0.051
Wetted Girth	15.708	m	15.71	m	0.013	15.71	m	0.013	15.71	m	0.013
BM	1.875	m	1.876	m	0.053	1.876	m	0.053	1.875	m	0.000

Table 2.2.1 Sphere Mesh Density 0.5-0.7 Results

5 m draft	Water Density 1025.9 kg/m ³		0.8 Mesh Density		% Error	0.9 Mesh Density		% Error	1.0 Mesh Density		% Error
	Analytic		Orca3D			Orca3D			Orca3D		
Displaced Volume	261.799	m ³	261.5	m ³	0.114	261.5	m ³	0.114	261.7	m ³	0.038
VCB	-1.875	m	-1.875	m	0.000	-1.875	m	0.000	-1.875	m	0.000
Area Moment of Inertia	490.874	m ⁴	490.5	m ⁴	0.076	490.5	m ⁴	0.076	490.8	m ⁴	0.015
Waterplane Area	78.540	m ²	78.51	m ²	0.038	78.51	m ²	0.038	78.53	m ²	0.012
Immersed Area	39.270	m ²	39.3	m ²	0.077	39.3	m ²	0.077	39.3	m ²	0.077
Wetted Surface	157.080	m ²	157.00	m ²	0.051	157.00	m ²	0.051	157.06	m ²	0.012
Wetted Girth	15.708	m	15.71	m	0.013	15.71	m	0.013	15.71	m	0.013
BM	1.875	m	1.875	m	0.000	1.875	m	0.000	1.875	m	0.000

Table 2.2.2 Sphere Mesh Density 0.8-1.0 Results

Model Sinkage = -1.0m	Water Density 1025.9 kg/m ³		Mesh Density 0.7		% Error
	Analytic		Orca3D		
Displaced Volume	184.307	m ³	181.4	m ³	1.577
VCB	-2.455	m	-2.454	m	0.022
Area Moment of Inertia	452.389	m ⁴	451.6	m ⁴	0.174
Waterplane Area	75.398	m ²	75.33	m ²	0.090
Immersed Area	29.337	m ²	29.3	m ²	0.126
Wetted Surface	125.664	m ²	125.59	m ²	0.059
Wetted Girth	13.694	m	13.69	m	0.032
BM	2.455	m	2.453	m	0.063

Table 2.2.3 Sphere Negative Sinkage Results

Model Sinkage = 1.0m	Water Density 1025.9 kg/m ³		Mesh Density 0.7		% Error
	Analytic		Orca3D		
Displaced Volume	339.292	m ³	339	m ³	0.086
VCB	-1.333	m	-1.333	m	0.025
Area Moment of Inertia	452.389	m ⁴	451.7	m ⁴	0.152
Waterplane Area	75.398	m ²	75.34	m ²	0.077
Immersed Area	49.203	m ²	49.2	m ²	0.006

Wetted Surface	188.496	m ²	188.41	m ²	0.045
Wetted Girth	17.722	m	17.72	m	0.009
BM	1.333	m	1.333	m	0.025

Table 2.2.4 Sphere Positive Sinkage Results

2.3 Vertical Cylinder Results

The vertical cylinder is 8 meters in diameter and 12 meters in length. The horizontal construction plane intersects the cylinder so that it has a 4 meter draft at 0 sinkage.

4 m draft	Water Density 1025.9 kg/m ³		0.5 Mesh Density		% Error	0.6 Mesh Density		% Error	0.7 Mesh Density		% Error
	Analytic		Orca3D			Orca3D			Orca3D		
Displaced Volume	201.062	m ³	200.7	m ³	0.180	200.7	m ³	0.180	200.7	m ³	0.180
VCB	-2.000	m	-2.000	m	0.000	-2.000	m	0.000	-2.000	m	0.000
Area Moment of Inertia	201.062	m ⁴	200.4	m ⁴	0.329	200.4	m ⁴	0.329	200.4	m ⁴	0.329
Waterplane Area	50.265	m ²	50.18	m ²	0.170	50.18	m ²	0.170	50.18	m ²	0.170
Immersed Area	32.000	m ²	32.0	m ²	0.000	32.0	m ²	0.000	32.0	m ²	0.000
Wetted Surface	150.796	m ²	150.67	m ²	0.084	150.67	m ²	0.084	150.67	m ²	0.084
Wetted Girth	16.000	m	16.00	m	0.000	16.00	m	0.000	16.00	m	0.000
BM	1.000	m	0.998	m	0.200	0.998	m	0.200	0.998	m	0.200

Table 2.3.1 Vertical Cylinder Mesh Density 0.5-0.7 Results

4 m draft	Water Density 1025.9 kg/m ³		0.8 Mesh Density		% Error	0.9 Mesh Density		% Error	1.0 Mesh Density		% Error
	Analytic		Orca3D			Orca3D			Orca3D		
Displaced Volume	201.062	m ³	201	m ³	0.031	201	m ³	0.031	201	m ³	0.031
VCB	-2.000	m	-2.000	m	0.000	-2.000	m	0.000	-2.000	m	0.000
Area Moment of Inertia	201.062	m ⁴	200.9	m ⁴	0.081	200.9	m ⁴	0.081	200.9	m ⁴	0.081
Waterplane Area	50.265	m ²	50.24	m ²	0.051	50.25	m ²	0.031	50.25	m ²	0.031
Immersed Area	32.000	m ²	32.0	m ²	0.000	32.0	m ²	0.000	32.0	m ²	0.000
Wetted Surface	150.796	m ²	150.76	m ²	0.024	150.77	m ²	0.018	150.77	m ²	0.018
Wetted Girth	16.000	m	16.00	m	0.000	16.00	m	0.000	16.00	m	0.000
BM	1.000	m	1.000	m	0.000	1.000	m	0.000	1.000	m	0.000

Table 2.3.2 Vertical Cylinder Mesh Density 0.8-1.0 Results

Model Sinkage = -1.0m	Water Density 1025.9 kg/m ³		Mesh Density 0.7		% Error
	Analytic		Orca3D		
Displaced Volume	150.796	m ³	150.6	m ³	0.130
VCB	-2.500	m	-2.500	m	0.000

Area Moment of Inertia	201.062	m ⁴	200.4	m ⁴	0.329
Waterplane Area	50.265	m ²	50.18	m ²	0.170
Immersed Area	24.000	m ²	24.0	m ²	0.000
Wetted Surface	125.664	m ²	125.55	m ²	0.090
Wetted Girth	14.000	m	14.00	m	0.000
BM	1.333	m	1.331	m	0.175

Table 2.3.3 Vertical Cylinder Negative Sinkage Results

Model Sinkage = 1.0m	Water Density 1025.9 kg/m ³		Mesh Density 0.7		% Error
	Analytic		Orca3D		
Displaced Volume	251.327	m ³	250.9	m ³	0.170
VCB	-1.500	m	-1.500	m	0.000
Area Moment of Inertia	201.062	m ⁴	200.4	m ⁴	0.329
Waterplane Area	50.265	m ²	50.18	m ²	0.170
Immersed Area	40.000	m ²	40.0	m ²	0.000
Wetted Surface	175.929	m ²	175.80	m ²	0.073
Wetted Girth	18.000	m	18.00	m	0.000
BM	0.800	m	0.799	m	0.125

Table 2.3.4 Vertical Cylinder Positive Sinkage Results

2.4 Cone Results

The cone has a base diameter of 7 meters and a height of 7 meters. The cone is orientated tip down and the horizontal construction plane intersects giving it a draft of 5 meters with 0 sinkage.

5 m draft	Water Density 1025.9 kg/m ³		0.5 Mesh Density		% Error	0.6 Mesh Density		% Error	0.7 Mesh Density		% Error
	Analytic		Orca3D			Orca3D			Orca3D		
Displaced Volume	32.725	m ³	32.7	m ³	0.076	32.7	m ³	0.076	32.7	m ³	0.076
VCB	-1.250	m	-1.25	m	0.000	-1.25	m	0.000	-1.25	m	0.000
Area Moment of Inertia	30.680	m ⁴	30.6	m ⁴	0.260	30.6	m ⁴	0.260	30.6	m ⁴	0.260
Waterplane Area	19.635	m ²	19.6	m ²	0.178	19.6	m ²	0.178	19.6	m ²	0.178
Immersed Area	12.500	m ²	12.5	m ²	0.000	12.5	m ²	0.000	12.5	m ²	0.000
Wetted Surface	43.905	m ²	43.88	m ²	0.057	43.88	m ²	0.057	43.88	m ²	0.057
Wetted Girth	11.180	m	11.18	m	0.003	11.18	m	0.003	11.18	m	0.003
BM	0.938	m	0.936	m	0.160	0.936	m	0.160	0.936	m	0.160

Table 2.4.1 Cone Mesh Density 0.5-0.7 Results

5 m draft	Water Density 1025.9 kg/m ³		0.8 Mesh Density		% Error	0.9 Mesh Density		% Error	1.0 Mesh Density		% Error
	Analytic		Orca3D			Orca3D			Orca3D		
Displaced Volume	32.725	m ³	32.7	m ³	0.076	32.7	m ³	0.076	32.7	m ³	0.076
VCB	-1.250	m	-1.25	m	0.000	-1.25	m	0.000	-1.25	m	0.000
Area Moment of Inertia	30.680	m ⁴	30.7	m ⁴	0.066	30.7	m ⁴	0.066	30.7	m ⁴	0.066
Waterplane Area	19.635	m ²	19.63	m ²	0.025	19.63	m ²	0.025	19.63	m ²	0.025
Immersed Area	12.500	m ²	12.5	m ²	0.000	12.5	m ²	0.000	12.5	m ²	0.000
Wetted Surface	43.905	m ²	43.9	m ²	0.012	43.9	m ²	0.012	43.9	m ²	0.012
Wetted Girth	11.180	m	11.18	m	0.003	11.18	m	0.003	11.18	m	0.003
BM	0.938	m	0.937	m	0.053	0.937	m	0.053	0.937	m	0.053

Table 2.4.2 Cone Mesh Density 0.8-1.0 Results

Model Sinkage = -1.0m	Water Density 1025.9 kg/m ³		Mesh Density 0.7		% Error
	Analytic		Orca3D		
Displaced Volume	16.755	m ³	16.7	m ³	0.329
VCB	-2.000	m	-2.000	m	0.000
Area Moment of Inertia	12.566	m ⁴	12.5	m ⁴	0.528
Waterplane Area	12.566	m ²	12.55	m ²	0.130
Immersed Area	8.000	m ²	8.0	m ²	0.000
Wetted Surface	28.099	m ²	28.08	m ²	0.069
Wetted Girth	8.944	m	8.94	m	0.048
BM	0.750	m	0.749	m	0.133

Table 2.4.3 Cone Negative Sinkage Results

Model Sinkage = 1.0m	Water Density 1025.9 kg/m ³		Mesh Density 0.7		% Error
	Analytic		Orca3D		
Displaced Volume	56.549	m ³	56.5	m ³	0.086
VCB	-0.500	m	-0.500	m	0.000
Area Moment of Inertia	63.617	m ⁴	63.4	m ⁴	0.341
Waterplane Area	28.274	m ²	28.23	m ²	0.157
Immersed Area	18.000	m ²	18.0	m ²	0.000
Wetted Surface	63.223	m ²	63.18	m ²	0.069
Wetted Girth	13.416	m	13.42	m	0.027
BM	1.125	m	1.123	m	0.178

Table 2.4.4 Cone Positive Sinkage Results

2.5 Horizontal Cylinder Results

The horizontal cylinder has a 6 meter diameter and a 10 meter length. It is orientated on its side with the horizontal construction plane intersecting it giving a 3 meter draft with 0 sinkage.

3 m draft	Water Density 1025.9 kg/m ³		0.5 Mesh Density		% Error	0.6 Mesh Density		% Error	0.7 Mesh Density		% Error
	Analytic		Orca3D			Orca3D			Orca3D		
Displaced Volume	141.372	m ³	141.1	m ³	0.192	141.1	m ³	0.192	141.1	m ³	0.192
VCB	-1.273	m	-1.272	m	0.097	-1.272	m	0.097	-1.272	m	0.097
Transverse Area Moment of Inertia	180.000	m ⁴	179.2	m ⁴	0.444	180	m ⁴	0.000	180	m ⁴	0.000
Longitudinal Area Moment of Inertia	500.000	m ⁴	499.3	m ⁴	0.140	500	m ⁴	0.000	500	m ⁴	0.000
Waterplane Area	60.000	m ²	59.91	m ²	0.150	60.0	m ²	0.000	60.0	m ²	0.000
Immersed Area	14.137	m ²	14.1	m ²	0.263	14.1	m ²	0.263	14.1	m ²	0.263
Wetted Surface	122.522	m ²	122.41	m ²	0.092	122.44	m ²	0.067	122.44	m ²	0.067
Wetted Girth	9.425	m	9.42	m	0.051	9.42	m	0.051	9.42	m	0.051
BMT	1.273	m	1.270	m	0.254	1.275	m	0.138	1.275	m	0.138
BML	3.537	m	3.539	m	0.063	3.543	m	0.176	3.543	m	0.176

Table 2.5.1 Horizontal Cylinder Mesh Density 0.5-0.7 Results

3 m draft	Water Density 1025.9 kg/m ³		0.8 Mesh Density		% Error	0.9 Mesh Density		% Error	1.0 Mesh Density		% Error
	Analytic		Orca3D			Orca3D			Orca3D		
Displaced Volume	141.372	m ³	141.3	m ³	0.051	141.3	m ³	0.051	141.3	m ³	0.051
VCB	-1.273	m	-1.273	m	0.019	-1.273	m	0.019	-1.273	m	0.019
Transverse Area Moment of Inertia	180.000	m ⁴	180	m ⁴	0.000	180	m ⁴	0.000	180	m ⁴	0.000
Longitudinal Area Moment of Inertia	500.000	m ⁴	500	m ⁴	0.000	500	m ⁴	0.000	500	m ⁴	0.000
Waterplane Area	60.000	m ²	60.0	m ²	0.000	60.0	m ²	0.000	60.0	m ²	0.000
Immersed Area	14.137	m ²	14.1	m ²	0.263	14.1	m ²	0.263	14.1	m ²	0.263
Wetted Surface	122.522	m ²	122.49	m ²	0.026	122.5	m ²	0.018	122.5	m ²	0.018
Wetted Girth	9.425	m	9.42	m	0.051	9.42	m	0.051	9.42	m	0.051
BMT	1.273	m	1.274	m	0.060	1.274	m	0.060	1.274	m	0.060
BML	3.537	m	3.539	m	0.063	3.538	m	0.035	3.538	m	0.035

Table 2.5.2 Horizontal Cylinder Mesh Density 0.8-1.0 Results

Model Sinkage = -1.0m	Water Density 1025.9 kg/m ³		Mesh Density 0.7		% Error
	Analytic		Orca3D		
Displaced Volume	82.502	m ³	82.3	m ³	0.245

VCB	-1.828	m	-1.827	m	0.078
Transverse Area Moment of Inertia	150.849	m ⁴	150.3	m ⁴	0.364
Longitudinal Area Moment of Inertia	471.405	m ⁴	470.9	m ⁴	0.107
Waterplane Area	56.569	m ²	56.50	m ²	0.121
Immersed Area	8.250	m ²	8.2	m ²	0.609
Wetted Surface	90.358	m ²	90.27	m ²	0.097
Wetted Girth	7.386	m	7.39	m	0.057
BMT	1.8284	m	1.826	m	0.133
BML	5.7139	m	5.719	m	0.090

Table 2.5.3 Horizontal Cylinder Negative Sinkage Results

Model Sinkage = 1.0m	Water Density 1025.9 kg/m ³		Mesh Density 0.7		% Error
	Analytic		Orca3D		
Displaced Volume	200.241	m ³	200	m ³	0.120
VCB	-0.753	m	-0.752	m	0.178
Transverse Area Moment of Inertia	150.849	m ⁴	150.3	m ⁴	0.364
Longitudinal Area Moment of Inertia	471.405	m ⁴	470.9	m ⁴	0.107
Waterplane Area	56.569	m ²	56.50	m ²	0.121
Immersed Area	20.024	m ²	20.0	m ²	0.120
Wetted Surface	154.686	m ²	154.61	m ²	0.049
Wetted Girth	11.464	m	11.46	m	0.033
BMT	0.7533	m	0.752	m	0.178
BML	2.3542	m	2.355	m	0.035

Table 2.5.4 Horizontal Cylinder Positive Sinkage Results

19.2 Free Float Verification

3 Free Float Verification

In order to verify the free float calculation option in Orca3D, hydrostatic and stability

properties were calculated by inputting weights at known drafts and verifying the results with analytic calculations. The comparisons for each shape are shown in the following subsections.

3.1 Cube Free Float Results

The 10 meter cube was verified using the following three input weights:

Water Density: 1025.9 kg/m ³	Input weight:		512,95 0.0	kg	
	Analytic		Orca3D		% Error
Draft	5.000	m	5.000	m	0.000
Displaced Volume	500.0 00	m ³	500.0	m ³	0.000
VCB	-2.500	m	-2.500	m	0.000
Area Moment of Inertia	833.3 30	m ⁴	833.3	m ⁴	0.004
Waterplane Area	100.0 00	m ²	100.00	m ²	0.000
Immersed Area	50.00 0	m ²	50.0	m ²	0.000
Wetted Surface	300.0 00	m ²	300.00	m ²	0.000
Wetted Girth	20.00 0	m	20.00	m	0.000
BM	1.667	m	1.667	m	0.020

Table 3.1.1 Cube Free Float Results Weight I

Water Density: 1025.9 kg/m ³	Input weight:		410,36 0.0	kg	
	Analytic		Orca3D		% Error
Draft	4.000	m	4.000	m	0.000
Displaced Volume	400.00 0	m ³	400.0	m ³	0.000
VCB	-3.000	m	-3.000	m	0.000
Area Moment of Inertia	833.33 3	m ⁴	833.3	m ⁴	0.004

Waterplane Area	100.00 0	m ²	100.00	m ²	0.000
Immersed Area	40.000	m ²	40.0	m ²	0.000
Wetted Surface	260.00 0	m ²	260.00	m ²	0.000
Wetted Girth	18.000	m	18.00	m	0.000
BM	2.083	m	2.083	m	0.016

Table 3.1.2 Cube Free Float Results Weight II

Water Density: 1025.9 kg/m ³	Input weight:		615,54 0.0	kg	
	Analytic		Orca3D		% Error
Draft	6.000	m	6.000	m	0.000
Displaced Volume	600.00 0	m ³	600.0	m ³	0.000
VCB	-2.000	m	-2.000	m	0.000
Area Moment of Inertia	833.33 3	m ⁴	833.3	m ⁴	0.004
Waterplane Area	100.00 0	m ²	100.00	m ²	0.000
Immersed Area	60.000	m ²	60.0	m ²	0.000
Wetted Surface	340.00 0	m ²	340.00	m ²	0.000
Wetted Girth	22.000	m	22.00	m	0.000
BM	1.389	m	1.389	m	0.008

Table 3.1.3 Cube Free Float Results Weight III

3.2 Sphere Free Float Results

The 10 meter diameter sphere was verified using the following three input weights:

Water Density: 1025.9 kg/m ³	Input weight:		268,580.0	kg	
	Analytic		Orca3D		% Error
Draft	5.000	m	5.003	m	0.060
Displaced Volume	261.799	m ³	261.8	m ³	0.000
VCB	-1.875	m	-1.873	m	0.107
Area Moment of Inertia	490.874	m ⁴	490.4	m ⁴	0.097
Waterplane Area	78.540	m ²	78.51	m ²	0.038
Immersed Area	39.270	m ²	39.3	m ²	0.077
Wetted Surface	157.080	m ²	157.11	m ²	0.019
Wetted Girth	15.708	m	15.72	m	0.077
BM	1.875	m	1.873	m	0.107

Table 3.2.1 Sphere Free Float Results Weight I

Water Density: 1025.9 kg/m ³	Input weight:		189,080.3	kg	
	Analytic		Orca3D		% Error
Draft	4.000	m	4.003	m	0.075
Displaced Volume	184.307	m ³	184.3	m ³	0.004
VCB	-2.455	m	-2.453	m	0.063
Area Moment of Inertia	452.389	m ⁴	451.8	m ⁴	0.130
Waterplane Area	75.398	m ²	75.35	m ²	0.064
Immersed Area	29.337	m ²	29.4	m ²	0.215

Wetted Surface	125.664	m ²	125.672	m ²	0.005
Wetted Girth	13.694	m	13.70	m	0.041
BM	2.455	m	2.451	m	0.144

Table 3.2.2 Sphere Free Float Results Weight II

Water Density: 1025.9 kg/m ³	Input weight:		348,079.7	kg	
	Analytic		Orca3D		% Error
Draft	6.000	m	6.004	m	0.067
Displaced Volume	339.292	m ³	339.3	m ³	0.002
VCB	-1.333	m	-1.331	m	0.175
Area Moment of Inertia	452.389	m ⁴	451.4	m ⁴	0.219
Waterplane Area	75.398	m ²	75.32	m ²	0.104
Immersed Area	49.203	m ²	49.3	m ²	0.197
Wetted Surface	188.496	m ²	188.54	m ²	0.024
Wetted Girth	17.722	m	17.73	m	0.048
BM	1.333	m	1.330	m	0.250

Table 3.2.3 Sphere Free Float Results Weight III

3.3 Vertical Cylinder Free Float Results

The 8 meter diameter, 12 meter high vertical cylinder was verified using the following three input weights:

Water Density: 1025.9 kg/m ³	Input weight:		206,26 9.4	kg	
	Analyt ic		Orca3 D		% Error
Draft	4.000	m	4.007	m	0.175
Displaced Volume	201.0 62	m ³	201.1	m ³	0.019
VCB	-2.000	m	-1.997	m	0.150
Area Moment of Inertia	201.0 62	m ⁴	200.4	m ⁴	0.329
Waterplane Area	50.26 5	m ²	50.18	m ²	0.170
Immersed Area	32.00 0	m ²	32.0	m ²	0.000
Wetted Surface	150.7 96	m ²	150.84	m ²	0.029
Wetted Girth	16.00 0	m	16.01	m	0.063
BM	1.000	m	0.997	m	0.300

Table 3.3.1 Vertical Cylinder Free Float Results Weight I

Water Density: 1025.9 kg/m ³	Input weight:		154,70 2.1	kg	
	Analyt ic		Orca3 D		% Error
Draft	3.000	m	3.005	m	0.167
Displaced Volume	150.79 6	m ³	150.8	m ³	0.002
VCB	-2.500	m	-2.498	m	0.080
Area Moment of Inertia	201.06 2	m ⁴	200.4	m ⁴	0.329
Waterplane Area	50.265	m ²	50.18	m ²	0.170
Immersed Area	24.000	m ²	24.0	m ²	0.000

Wetted Surface	125.664	m ²	125.67	m ²	0.005
Wetted Girth	14.000	m	14.01	m	0.071
BM	1.333	m	1.329	m	0.325

Table 3.3.2 Vertical Cylinder Free Float Results Weight II

Water Density: 1025.9 kg/m ³	Input weight:	257,836.8	kg		
	Analytic		Orca3D		% Error
Draft	5.000	m	5.008	m	0.160
Displaced Volume	251.327	m ³	251.3	m ³	0.011
VCB	-1.500	m	-1.496	m	0.267
Area Moment of Inertia	201.062	m ⁴	200.4	m ⁴	0.329
Waterplane Area	50.265	m ²	50.18	m ²	0.170
Immersed Area	40.000	m ²	40.1	m ²	0.250
Wetted Surface	175.929	m ²	176.00	m ²	0.040
Wetted Girth	18.000	m	18.02	m	0.111
BM	0.800	m	0.797	m	0.375

Table 3.3.3 Vertical Cylinder Free Float Results Weight III

3.4 Cone Free Float Results

The 7 meter base diameter, 7 meter high cone was verified using the following three input weights:

Water Density: 1025.9 kg/m ³	Input weight:		33,572 .5	kg	
	Analyt ic		Orca3 D		% Error
Draft	5.000	m	5.003	m	0.060
Displaced Volume	32.72 5	m ³	32.7	m ³	0.076
VCB	-1.250	m	-1.248	m	0.160
Area Moment of Inertia	30.68 0	m ⁴	30.6	m ⁴	0.260
Waterplane Area	19.63 5	m ²	19.62	m ²	0.076
Immersed Area	12.50 0	m ²	12.5	m ²	0.000
Wetted Surface	43.90 5	m ²	43.92	m ²	0.034
Wetted Girth	11.18 0	m	11.19	m	0.086
BM	0.938	m	0.936	m	0.160

Table 3.4.1 Cone Free Float Results Weight I

Water Density: 1025.9 kg/m ³	Input weight:		17,189 .1	kg	
	Analyt ic		Orca3 D		% Error
Draft	4.000	m	4.002	m	0.050
Displaced Volume	16.755	m ³	16.8	m ³	0.268
VCB	-2.000	m	-1.998	m	0.100
Area Moment of Inertia	12.566	m ⁴	12.6	m ⁴	0.268
Waterplane Area	12.566	m ²	12.56	m ²	0.051
Immersed Area	8.000	m ²	8.0	m ²	0.000

Wetted Surface	28.099	m ²	28.11	m ²	0.038
Wetted Girth	8.944	m	8.95	m	0.064
BM	0.750	m	0.749	m	0.133

Table 3.4.2 Cone Free Float Results Weight II

Water Density: 1025.9 kg/m^3	Input weight:		58,013 .3	kg	
	Analyt ic		Orca3 D		% Error
Draft	6.000	m	6.003	m	0.050
Displaced Volume	56.54 9	m^ 3	56.5	m^ 3	0.086
VCB	-0.500	m	-0.498	m	0.400
Area Moment of Inertia	63.61 7	m^ 4	63.5	m^ 4	0.184
Waterplane Area	28.27 4	m^ 2	28.26	m^ 2	0.051
Immersed Area	18.00 0	m^ 2	18.0	m^ 2	0.000
Wetted Surface	63.22 3	m^ 2	63.25	m^ 2	0.042
Wetted Girth	13.41 6	m	13.42	m	0.027
BM	1.125	m	1.124	m	0.089

Table 3.4.3 Cone Free Float Test Results Weight III

3.5 Horizontal Cylinder Free Float Results

The 6 meter diameter, 10 meter length horizontal cylinder was verified using the following three input weights:

Water Density: 1025.9 kg/m ³	Input weight:		145,033.2	kg	
	Analytic		Orca3D		% Error
Draft	3.000	m	3.004	m	0.133
Displaced Volume	141.372	m ³	141.4	m ³	0.020
VCB	-1.273	m	-1.27	m	0.254
Transverse Area Moment of Inertia	180.000	m ⁴	180.0	m ⁴	0.000
Longitudinal Area Moment of Inertia	500.000	m ⁴	500.0	m ⁴	0.000
Waterplane Area	60.000	m ²	60.00	m ²	0.000
Immersed Area	14.137	m ²	14.2	m ²	0.444
Wetted Surface	122.522	m ²	122.56	m ²	0.031
Wetted Girth	9.425	m	9.43	m	0.055
BMT	1.273	m	1.273	m	0.019
BML	3.537	m	3.537	m	0.006

Table 3.5.1 Horizontal Cylinder Free Float Results Weight I

Water Density: 1025.9 kg/m ³	Input weight:		84,638.8	kg	
	Analytic		Orca3D		% Error
Draft	2.000	m	2.003	m	0.150
Displaced Volume	82.502	m ³	82.5	m ³	0.002
VCB	-1.828	m	-1.826	m	0.133

Transverse Area Moment of Inertia	150.84 9	m ⁴ 4	150.5	m ⁴ 4	0.232
Longitudinal Area Moment of Inertia	471.40 5	m ⁴ 4	471.0	m ⁴ 4	0.086
Waterplane Area	56.569	m ² 2	56.53	m ² 2	0.068
Immersed Area	8.250	m ² 2	8.3	m ² 2	0.604
Wetted Surface	90.358	m ² 2	90.37	m ² 2	0.013
Wetted Girth	7.386	m	7.39	m	0.057
BMT	1.828	m	1.824	m	0.242
BML	5.714	m	5.71	m	0.067

Table 3.5.2 Horizontal Cylinder Free Float Results Weight II

Water Density: 1025.9 kg/m ³	Input weight:		205,42 7.5	kg	
	Analyt ic		Orca3 D		% Error
Draft	4.000	m	4.005	m	0.125
Displaced Volume	200.2 41	m ³ 3	200.2	m ³ 3	0.021
VCB	-0.753	m	-0.75	m	0.443
Transverse Area Moment of Inertia	150.8 49	m ⁴ 4	150.0	m ⁴ 4	0.563
Longitudinal Area Moment of Inertia	471.4 05	m ⁴ 4	470.5	m ⁴ 4	0.192
Waterplane Area	56.56 9	m ² 2	56.47	m ² 2	0.174
Immersed Area	20.02 4	m ² 2	20.1	m ² 2	0.379
Wetted Surface	154.6 86	m ² 2	154.77	m ² 2	0.054
Wetted Girth	11.46 4	m	11.47	m	0.054

BMT	0.753	m	0.749	m	0.576
BML	2.354	m	2.35	m	0.178

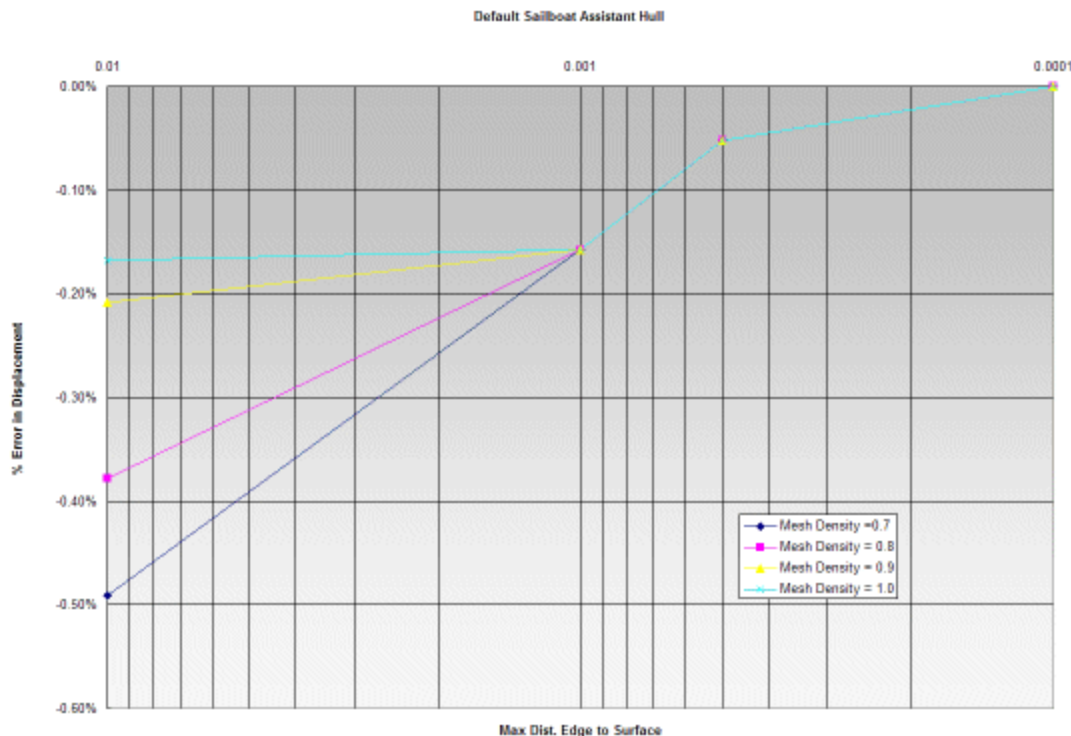
Table 3.5.3 Horizontal Cylinder Free Float Results Weight III

19.3 Mesh Density Accuracies

4 Mesh Density Accuracies

The following plot shows the error in displacement for a range of Density and Max Dist., Edge to Surf values, using the default sailboat hull from the Sailboat Hull Assistant, with a length of 10 meters. This hull is especially sensitive to these settings, because it has a relatively sparse control net and a lot of curvature (hulls like the Planing Hull Assistant hull or the Ship Hull Assistant hull which have less curvature, or hulls created with Rhino's loft command and will therefore have many more control points, will not be as sensitive).

In the plot, the value of 0.01 for Max Dist. is equivalent to leaving that value at 0, since the Density setting implies a finer mesh. Note that once the Max Dist. value gets down to 1 mm, the error is insensitive to the Density setting, since the Max Dist. values implies a finer mesh than the Density setting. With Max Dist. effectively "turned off" (left at 0, or set to a high value such as 0.01), the results are sensitive to the Density setting. The default Density setting in Orca3D is 1, which gives very good results. If you would like to increase the speed of the calculations, and are willing to accept a somewhat less accurate result, you can decrease the Density setting.



The following plots show the reduction in percent error for various parameters as the Orca3D mesh density is increased for basic shapes. The cube is not included in the plots since the accuracy is not affected by lower mesh densities.

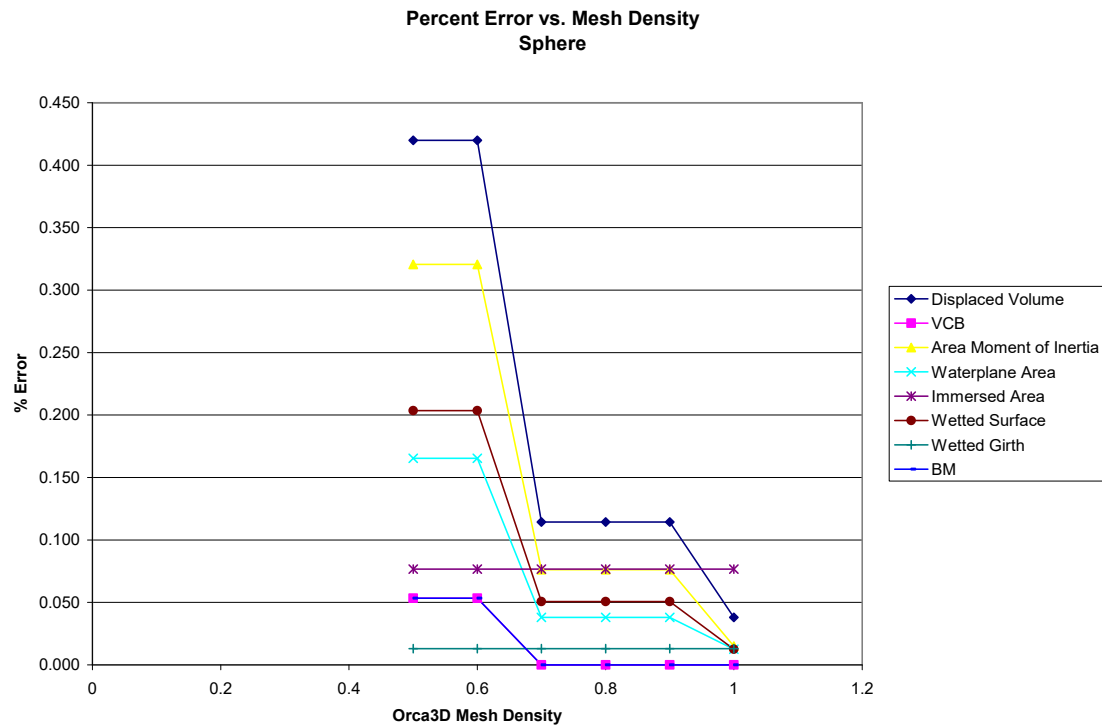


Figure 4.1 Sphere Mesh Density Accuracy

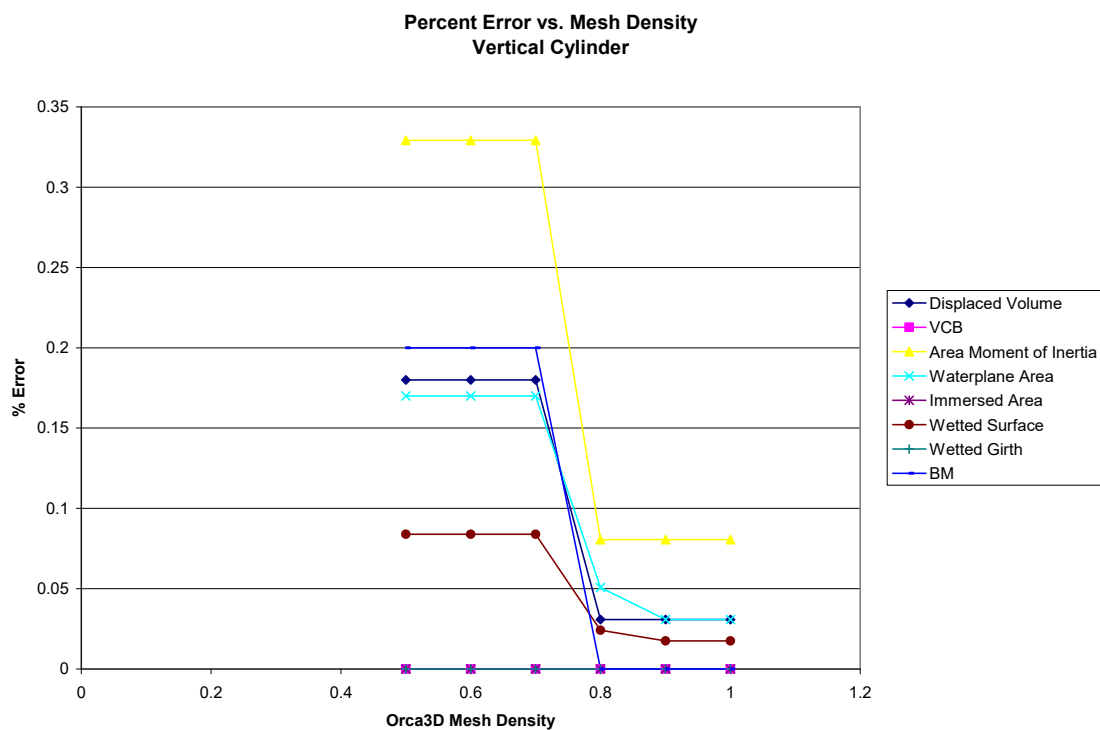


Figure 4.2 Vertical Cylinder Mesh Density Accuracy

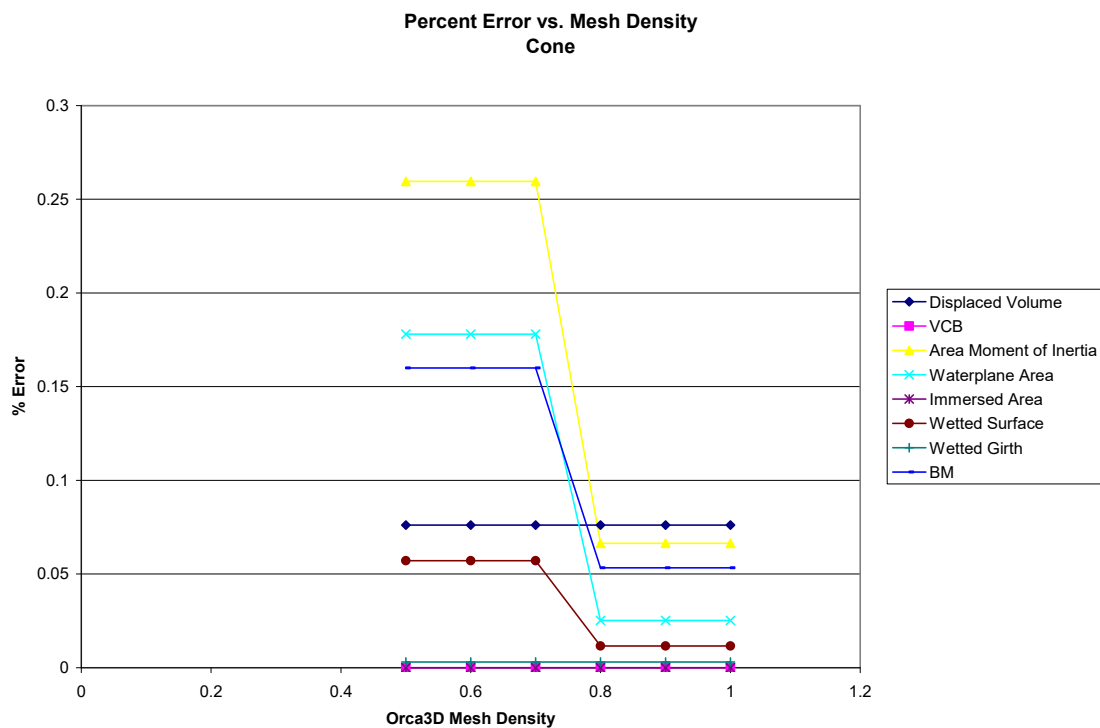


Figure 4.3 Cone Mesh Density Accuracy

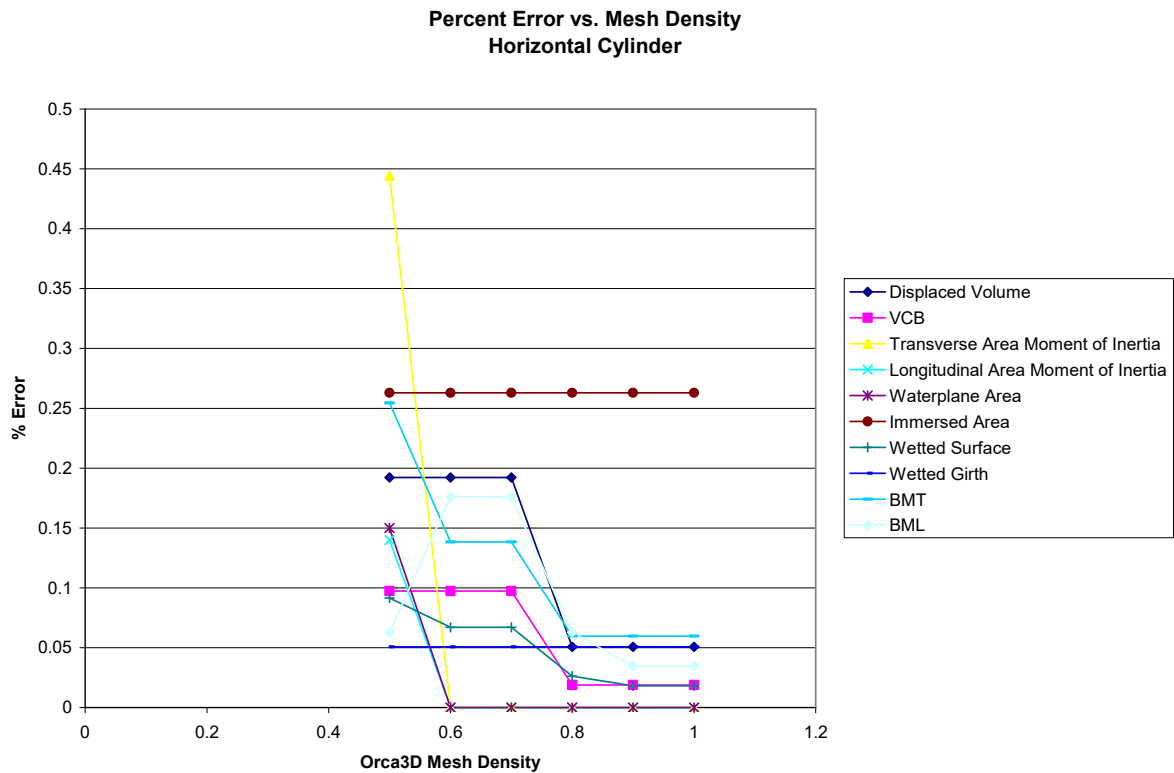


Figure 4.4 Horizontal Cylinder Density Accuracy

19.4 Righting Arm Curves

5 Righting Arm Curves

Orca3D righting arm calculations were verified using the sphere and horizontal cylinder from previous sections. When the VCG was located at the centroid of the shape, it was verified that the righting arm curve remained 0 for heel angles of 0-90 degrees. For VCGs not at the centroid, the following plots were produced from Orca3D data. As expected, the righting arm curve followed a sine curve.

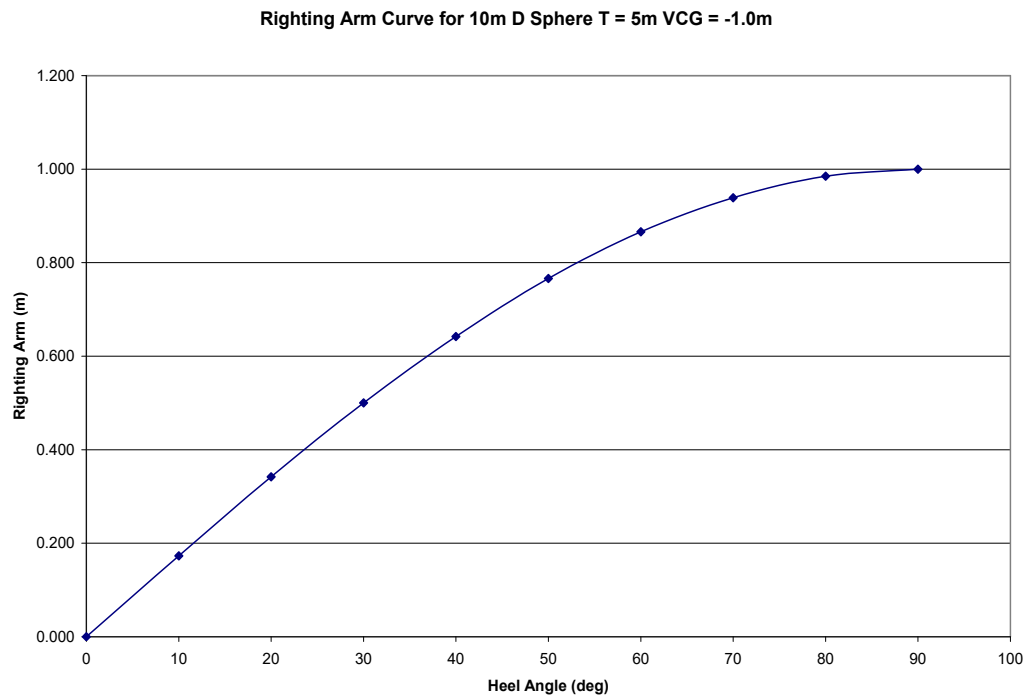


Figure 5.1 Righting Arm Curve for 10m D Sphere VCG = -1.0m

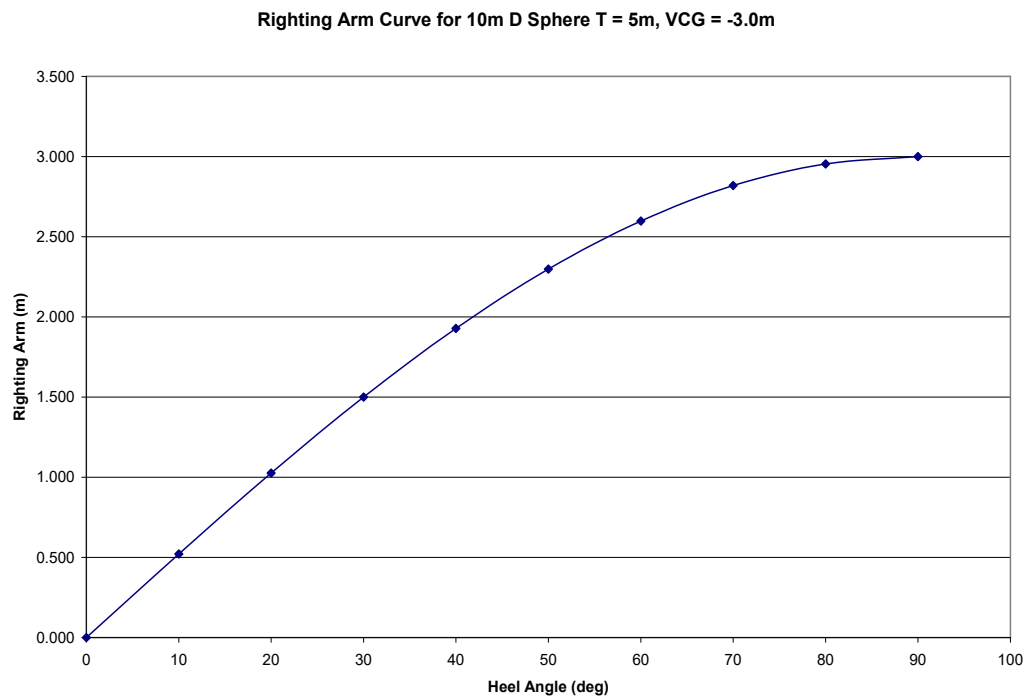


Figure 5.2 Righting Arm Curve for 10m D Sphere VCG = -3.0m

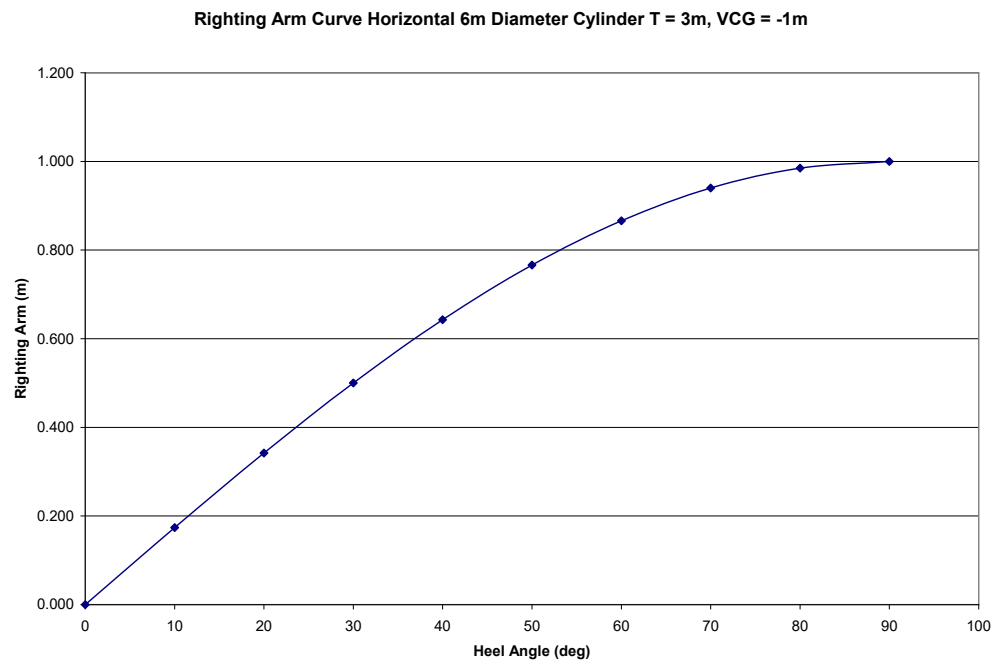


Figure 5.3 Righting Arm Curve for 6m D Horizontal Cylinder VCG = -1.0m

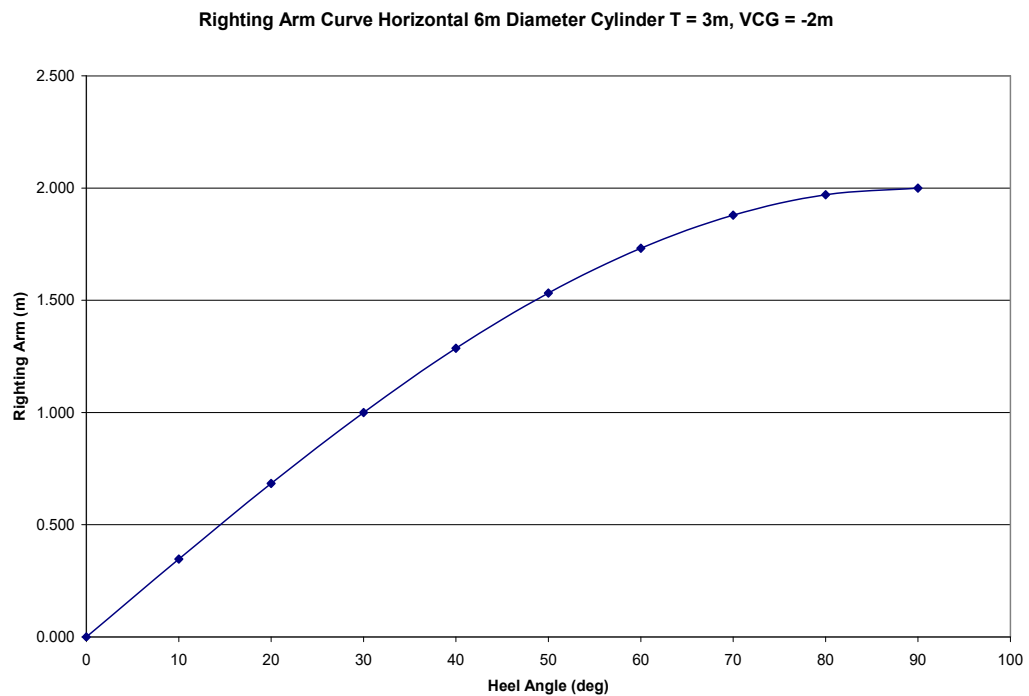
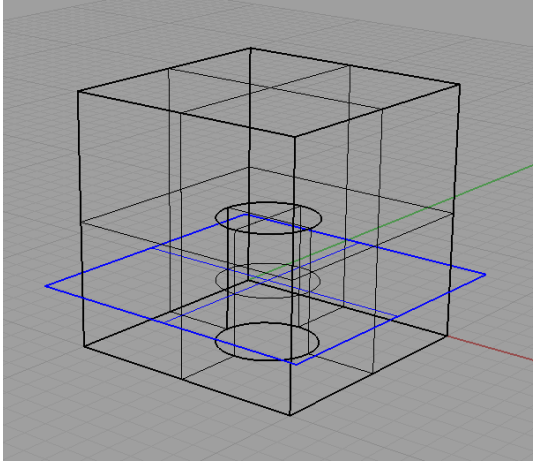


Figure 5.4 Righting Arm Curve for 6m D Horizontal Cylinder VCG = -2.0m

19.5 Cylinder in a Box Validation

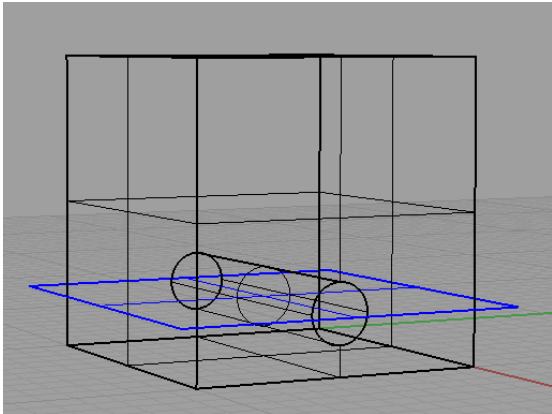
Cylinder in Box Hydrostatics Validation Test

The first model tested is a 10 meter cube with a vertical cylinder inside. The cylinder has a 2 meter radius and a height of 5 meters starting from the bottom of the cube. The bottom of the cylinder is open and its submerged volume is a loss of buoyancy. The blue plane represents the waterplane location for the validation test.



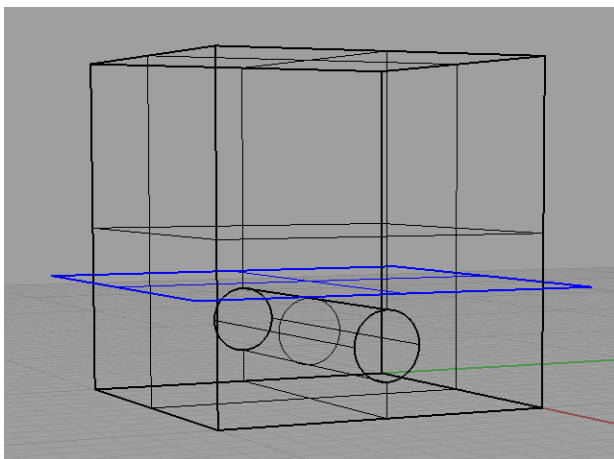
<i>2.5 meter draft</i>	Analyti c	Orca3D	% Diff
Displaced Volume	218.584	218.60 0	0.0072 9
VCB	1.250	1.250	0.0000 0
Area Moment of Inertia	820.767	820.80 0	0.0040 3
Waterplane Area	87.434	87.450	0.0187 2
Immersed Station Area	15.000	15.003	0.0200 0
Wetted Surface	218.850	218.86 0	0.0047 7
Wetted Station Girth	16.000	16.000	0.0000 0
BM	3.755	3.754	0.0246 5

The next two tests involve a model that is a 10 meter cube with a horizontal cylinder inside extending the full length of the cube. The cylinder has a radius of 1 meter and its centroid is located 2 meters from the bottom edge of the cube. The first test assumed the waterplane to intersect the cylinder as can be seen from the image below.



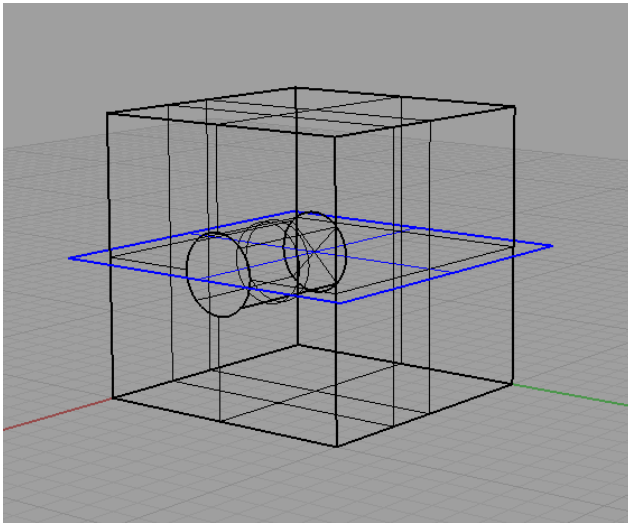
<i>2.0 meter draft</i>	Analyti c	Orca3D	% Diff
Displaced Volume	184.292	184.30 0	0.0043 2
VCB	0.951	0.951	0.0062 7
Transverse Area Moment of Inertia	826.667	826.70 0	0.0040 3
Longitudinal Area Moment of Inertia	666.667	666.80 0	0.0200 0
Waterplane Area	80.000	80.020	0.0250 0
Immersed Station Area	18.429	18.430	0.0043 2
Wetted Surface	208.274	208.28 0	0.0027 2
Wetted Station Girth	17.142	17.142	0.0023 8
BMt	4.486	4.485	0.0141 4
BMI	3.617	3.618	0.0152 9

The second test assumed the cylinder to be fully submerged.



<i>3.5 meter draft</i>	Analytic	Orca3D	% Diff
Displaced Volume	318.584	318.600	0.00500
VCB	1.725	1.725	0.02012
Area Moment of Inertia	833.333	833.300	0.00400
Waterplane Area	100.000	100.000	0.00000
Immersed Station Area	31.858	31.858	0.00128
Wetted Surface	296.549	296.560	0.00382
Wetted Station Girth	23.283	23.283	0.00080
BM	2.616	2.615	0.02832

The last test involved a horizontal cylinder with a radius of $\sqrt{2}$ meters inserted halfway into a 10 meter box. The waterline intersects the cylinder at its centroid.



5.0 meter draft	Analytic	Orca3D	% Diff
Displaced Volume	484.292	484.300	0.00164
VCB	2.438	2.438	0.01561
Transverse Area Moment of Inertia	823.905	823.900	0.00064
Longitudinal Area Moment of Inertia	700.923	700.900	0.00332
Waterplane Area	85.858	85.860	0.00249
Immersed Station Area	46.858	46.857	0.00300
Wetted Surface	322.214	322.210	0.00137
Wetted Station Girth	24.443	24.443	0.00048
BMt	1.701	1.701	0.01511
BMI	1.447	1.447	0.02178

19.6 Verification with various hull shapes

In addition to verifying Orca3D's results with primitive shapes, we have run a number of comparisons with GHS™, an industry standard for hydrostatics and stability calculations. GHS is written and distributed by Creative Systems, Inc., of Port Townsend, WA.

The following presents the hydrostatic results for four different hulls. The first three were created in Orca3D and are the standard planing, sailing, and ship type hulls produced by the Hull Assistants. The fourth is a containership hull that was imported from a '.GF' file as a mesh. CG height is on the baseline for each case, and mesh density is listed on each table. Each hull was evaluated at three drafts. Variation in the righting arm curves is shown in the graphs following each table.

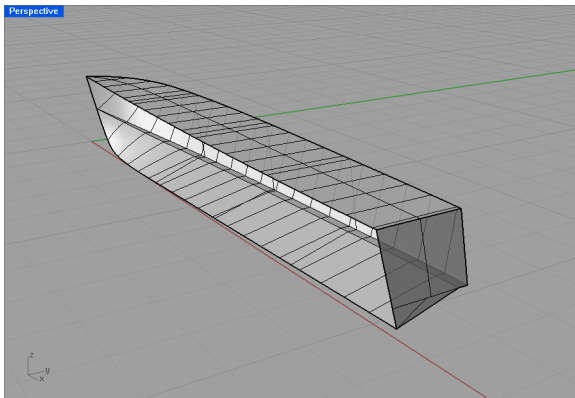
The maximum difference is highlighted in red, and all differences above 1% are highlighted in yellow.

Explanation of Differences Greater than 1%:

The sectional area coefficient is calculated using different beam and depth values. GHS values are higher because in its calculations, the local beam and depth are used in place of the maximum beam and depth. While these two values can be the same, they are not always as seen prominently in the Orca Planing example and also in the Orca Sailing example.

The length used in calculating the form coefficients can be calculated two different ways. If no length is previously specified, GHS calculates the length as 'the length of the rectangular block which circumscribes the immersed volume of the component.' Orca, however, uses the length of the current waterline. In the case of the containership hull, which has a bulbous bow, this length can vary by the length of the bulb (12 meters), causing any coefficients which use this length to be up to 4.6% different, depending on the draft at which they are evaluated. A raked stern will also cause these values to differ, such as in the Orca Planing example, which has a transom rake angle of 22 degrees.

The wetted surface calculations are also approached using two different methods. GHS uses section integration, which relies heavily on closely spaced stations and linear approximations. These values, according to the GHS help file, have a 2% error margin. Orca3D, however, uses the actual area of the submerged surfaces and does not rely on linear approximations.



Orca3D Planing Hull:

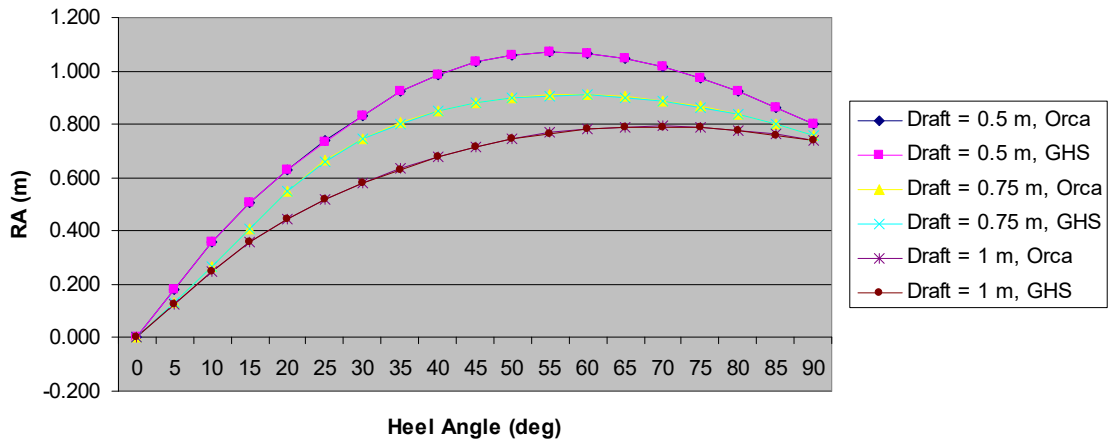
Figure 1: Orca3D Planing Half Hull

Table 1: Planing Hull Hydrostatics and Righting Arm Curve

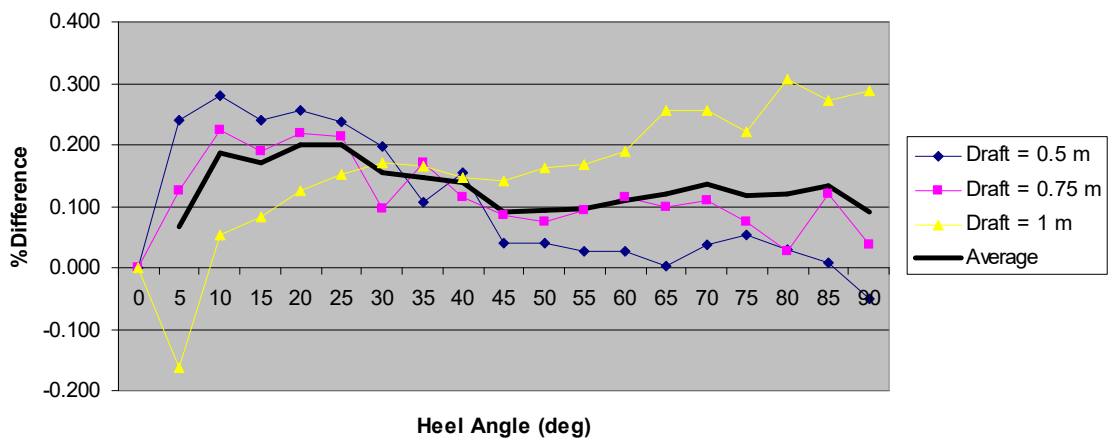
Mesh Density y		Draft = 0.5 m			Draft = 0.75 m			Draft = 1 m		
		Orca	GHS	%Diff	Orca	GHS	%Diff	Orca	GHS	%Diff
Disp	t	6.57	6.58	0.221	12.39	12.40	0.089	18.57	18.59	0.081
LCB	m	5.87	5.86	0.147	5.85	5.85	0.139	5.79	5.79	0.119
VCB	m	0.34	0.34	0.076	0.47	0.47	0.013	0.61	0.61	0.016
WSA	m ²	26.29	26.27	0.085	32.33	32.50	0.526	38.40	38.25	0.392
Awp	m ²	21.97	21.98	0.037	23.43	23.44	0.056	24.82	24.83	0.043
LCF	m	5.93	5.93	0.051	5.75	5.75	0.096	5.59	5.59	0.101
BMt	m	1.71	1.71	0.315	1.06	1.06	0.271	0.82	0.82	0.170
BMI	m	22.08	22.05	0.123	12.90	12.89	0.067	9.33	9.33	0.041
GMt	m	2.05	2.05	0.147	1.53	1.53	0.131	1.43	1.43	0.210
GMI	m	22.42	22.39	0.134	13.37	13.37	0.000	9.93	9.94	0.101
Cb		0.524	0.517	1.330	0.617	0.602	2.472	0.652	0.630	3.451
Cp		0.800	0.788	1.526	0.838	0.818	2.497	0.850	0.821	3.577
Cwp		0.899	0.899	0.034	0.898	0.897	0.057	0.893	0.894	0.067
Cx		0.655	0.700	6.453	0.736	0.773	4.817	0.766	0.797	3.836

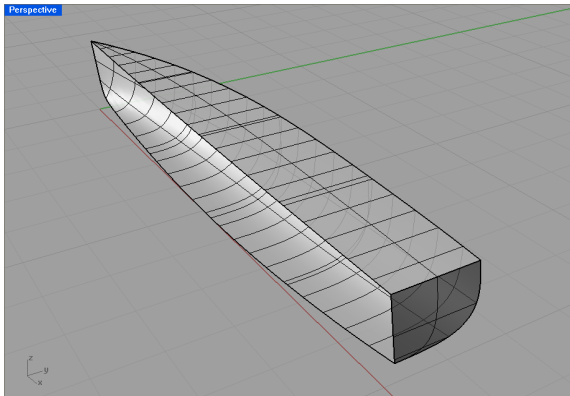
Cvp		0.583	0.585	0.421	0.687	0.689	0.244	0.730	0.731	0.204
RA	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
m	5	0.179	0.179	0.239	0.134	0.134	0.126	0.125	0.125	0.162
	10	0.357	0.356	0.280	0.270	0.269	0.223	0.250	0.250	0.054
	15	0.505	0.504	0.239	0.408	0.407	0.189	0.358	0.358	0.082
	20	0.629	0.627	0.256	0.549	0.548	0.219	0.445	0.444	0.125
	25	0.737	0.735	0.237	0.663	0.662	0.213	0.517	0.516	0.151
	30	0.835	0.833	0.198	0.745	0.744	0.097	0.579	0.578	0.171
	35	0.922	0.921	0.108	0.804	0.803	0.170	0.633	0.632	0.166
	40	0.988	0.986	0.155	0.848	0.847	0.115	0.679	0.678	0.147
	45	1.032	1.032	0.040	0.879	0.878	0.086	0.716	0.715	0.142
	50	1.059	1.059	0.040	0.899	0.898	0.074	0.745	0.744	0.163
	55	1.069	1.069	0.027	0.909	0.908	0.092	0.767	0.766	0.168
	60	1.063	1.063	0.027	0.910	0.909	0.114	0.782	0.781	0.189
	65	1.044	1.044	0.003	0.903	0.902	0.099	0.791	0.789	0.256
	70	1.013	1.013	0.038	0.888	0.887	0.110	0.793	0.791	0.257
	75	0.973	0.972	0.053	0.866	0.865	0.074	0.789	0.787	0.222
	80	0.922	0.922	0.029	0.836	0.836	0.028	0.778	0.776	0.306
	85	0.864	0.864	0.009	0.800	0.799	0.121	0.762	0.760	0.273
	90	0.799	0.799	0.051	0.757	0.757	0.037	0.740	0.738	0.287

Graph 1: Planing Hull Righting Arm Comparison



Graph 2: Planing Hull Righting Arm Curve Variation





Orca3D Sailing Hull:

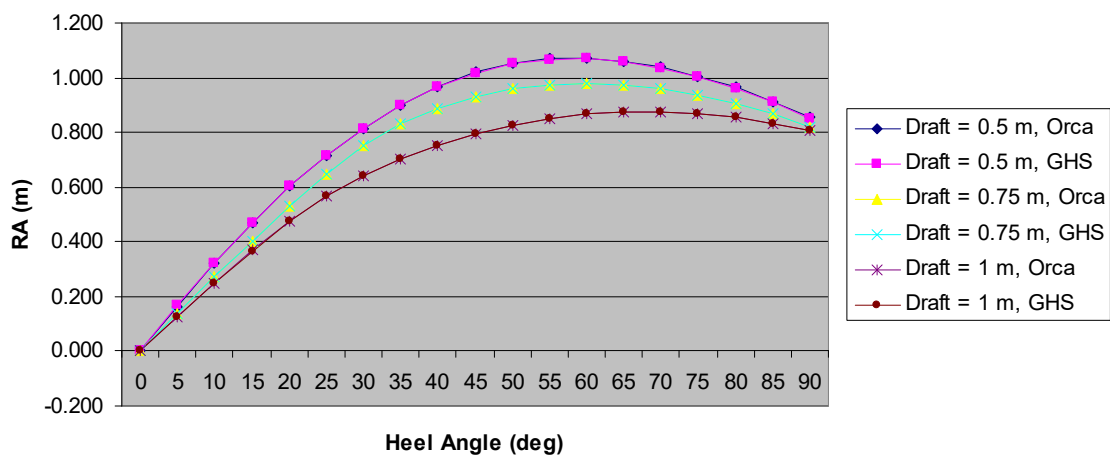
Figure 2: Orca3D Sailing Half Hull

Table 2: Sailing Hull Hydrostatics and Righting Arm Curve

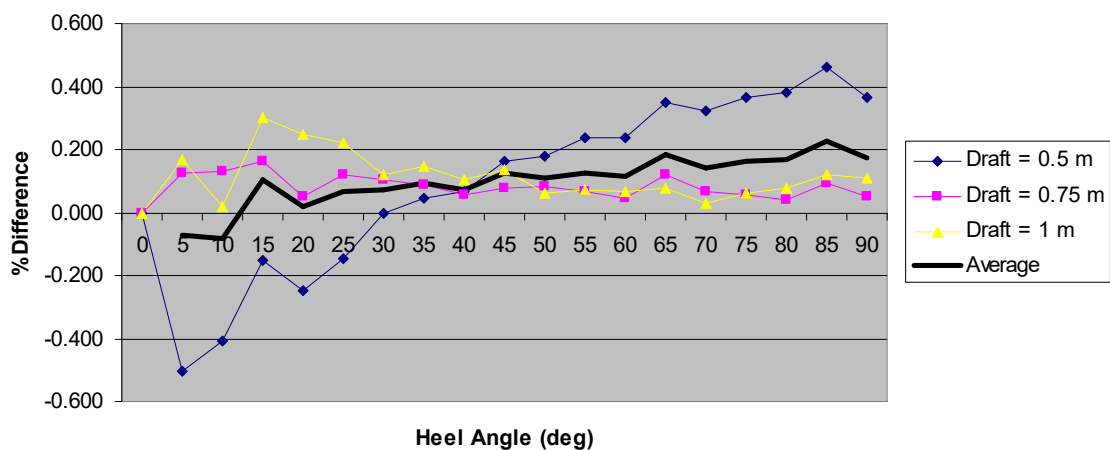
Mesh Density 0.7		Draft = 0.5 m			Draft = 0.75 m			Draft = 1 m		
		Orca	GHS	%Diff	Orca	GHS	%Diff	Orca	GHS	%Diff
Disp	t	6.45	6.48	0.414	12.14	12.17	0.279	18.18	18.21	0.177
LCB	m	5.45	5.44	0.103	5.64	5.63	0.098	5.71	5.70	0.073
VCB	m	0.31	0.32	0.113	0.46	0.46	0.004	0.60	0.60	0.032
WSA	m ²	23.20	23.24	0.187	29.53	30.08	1.831	35.34	35.98	1.771
Awp	m ²	20.73	20.78	0.240	23.11	23.13	0.073	23.86	23.87	0.044
LCF	m	5.80	5.80	0.078	5.86	5.86	0.016	5.83	5.83	0.011
BMt	m	1.59	1.59	0.263	1.11	1.11	0.158	0.81	0.81	0.241
BMI	m	18.93	18.88	0.250	12.11	12.10	0.086	8.48	8.47	0.114
GMt	m	1.90	1.91	0.419	1.58	1.57	0.445	1.41	1.41	0.000
GMI	m	19.24	19.20	0.208	12.57	12.56	0.080	9.08	9.07	0.110
Cb		0.468	0.469	0.184	0.549	0.55	0.139	0.601	0.60	0.676
Cp		0.581	0.585	0.754	0.661	0.66	0.267	0.702	0.70	0.465
Cwp		0.771	0.771	0.005	0.804	0.81	0.138	0.809	0.81	0.018
Cx		0.806	0.816	1.186	0.830	0.84	1.436	0.856	0.87	1.284
Cvp		0.607	0.609	0.303	0.683	0.68	0.200	0.743	0.75	0.295
RA	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

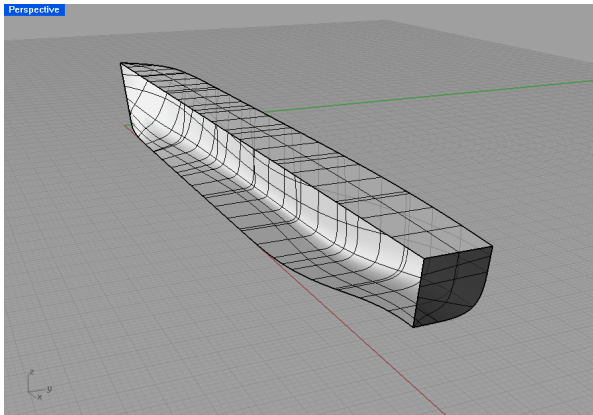
m	5	0.165	0.166	-0.506	0.137	0.137	0.123	0.123	0.123	0.170
	10	0.324	0.325	-0.407	0.272	0.272	0.131	0.246	0.246	0.021
	15	0.470	0.471	-0.151	0.404	0.403	0.165	0.368	0.367	0.300
	20	0.602	0.603	-0.246	0.529	0.529	0.051	0.478	0.477	0.249
	25	0.716	0.717	-0.146	0.648	0.647	0.123	0.567	0.566	0.219
	30	0.814	0.814	-0.003	0.751	0.750	0.104	0.641	0.640	0.119
	35	0.897	0.897	0.046	0.830	0.829	0.088	0.702	0.701	0.145
	40	0.968	0.967	0.066	0.888	0.888	0.056	0.753	0.752	0.102
	45	1.020	1.018	0.163	0.931	0.930	0.078	0.794	0.793	0.136
	50	1.053	1.051	0.177	0.959	0.958	0.085	0.827	0.826	0.064
	55	1.070	1.067	0.235	0.975	0.974	0.064	0.851	0.850	0.070
	60	1.072	1.069	0.235	0.979	0.979	0.046	0.867	0.866	0.065
	65	1.061	1.057	0.348	0.974	0.973	0.120	0.875	0.874	0.079
	70	1.038	1.035	0.323	0.960	0.959	0.068	0.875	0.875	0.031
	75	1.006	1.002	0.366	0.937	0.936	0.055	0.869	0.868	0.060
	80	0.964	0.960	0.382	0.905	0.905	0.042	0.855	0.854	0.078
	85	0.913	0.909	0.462	0.867	0.866	0.095	0.834	0.833	0.122
	90	0.855	0.852	0.366	0.821	0.821	0.052	0.807	0.806	0.109

Graph 3: Sailing Hull Righting Arm Comparison



Graph 4: Sailing Hull Righting Arm Curve Variation





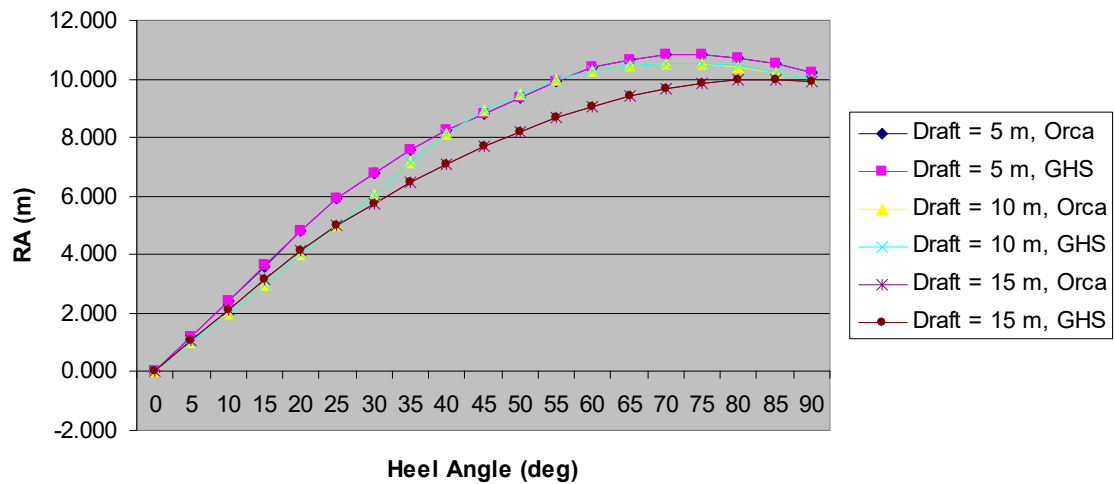
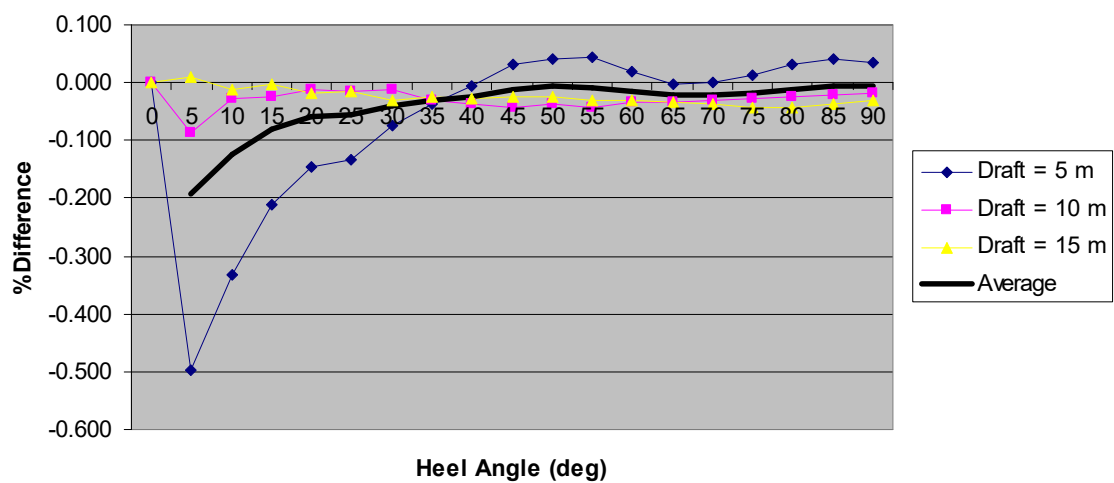
Orca3D Ship Hull:

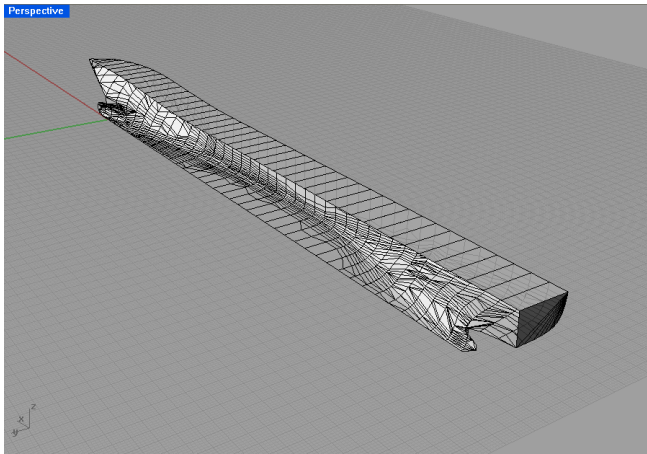
Figure 3: Orca3D Ship Half Hull

Table 3: Ship Hull Hydrostatics and Righting Arm Curve

Mesh Density	0.8 y	Draft = 5 m			Draft = 10 m			Draft = 15 m		
		Orca	GHS	%Diff	Orca	GHS	%Diff	Orca	GHS	%Diff
Disp	t	11,314	11,294	0.173	27,477	27,424	0.192	45,543	45,461	0.181
LCB	m	78.03	78.04	0.014	81.45	81.45	0.002	82.81	82.81	0.009
VCB	m	2.82	2.82	0.111	5.63	5.63	0.038	8.36	8.36	0.027
WSA	m²	3,525	3,502	0.677	5,434	5,422	0.238	7,153	7,141	0.170
Awp	m²	2,792	2,794	0.040	3,420	3,418	0.075	3,615	3,613	0.055
LCF	m	79.96	80.05	0.113	85.92	85.95	0.035	83.74	83.75	0.011
BMt	m	10.95	10.96	0.138	5.74	5.73	0.111	3.82	3.82	0.126
BMI	m	302.52	303.14	0.206	217.21	217.29	0.039	149.19	149.26	0.049
GMt	m	13.77	13.79	0.109	11.37	11.36	0.079	12.18	12.18	0.008
GMI	m	305.33	305.96	0.206	222.83	222.92	0.040	157.55	157.62	0.044
Cb		0.671	0.671	0.003	0.697	0.696	0.111	0.75	0.750	0.145
Cp		0.687	0.686	0.166	0.706	0.704	0.225	0.758	0.757	0.112
Cwp		0.850	0.850	0.041	0.890	0.889	0.097	0.917	0.917	0.046

Cx		0.977	0.980	0.352	0.988	0.980	0.767	0.991	0.992	0.092
Cvp		0.790	0.789	0.096	0.783	0.783	0.001	0.819	0.818	0.085
RA m	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	5	1.202	1.208	-0.497	0.992	0.993	-0.087	1.063	1.063	0.009
	10	2.407	2.415	-0.333	1.986	1.987	-0.028	2.126	2.126	-0.011
	15	3.614	3.622	-0.211	2.985	2.986	-0.025	3.183	3.183	-0.004
	20	4.805	4.812	-0.145	3.993	3.993	-0.012	4.136	4.137	-0.020
	25	5.896	5.904	-0.132	5.015	5.016	-0.015	4.984	4.985	-0.015
	30	6.806	6.811	-0.075	6.063	6.064	-0.013	5.754	5.756	-0.030
	35	7.573	7.576	-0.036	7.141	7.143	-0.032	6.457	6.459	-0.025
	40	8.239	8.239	-0.005	8.118	8.121	-0.037	7.098	7.100	-0.027
	45	8.833	8.830	0.030	8.902	8.906	-0.042	7.678	7.680	-0.025
	50	9.386	9.382	0.042	9.503	9.507	-0.038	8.198	8.200	-0.025
	55	9.924	9.920	0.043	9.951	9.955	-0.042	8.658	8.661	-0.030
	60	10.375	10.373	0.019	10.265	10.269	-0.035	9.059	9.062	-0.030
	65	10.670	10.670	-0.002	10.462	10.465	-0.032	9.396	9.399	-0.034
	70	10.814	10.814	0.000	10.550	10.553	-0.031	9.658	9.662	-0.037
	75	10.825	10.824	0.014	10.538	10.541	-0.028	9.842	9.846	-0.044
	80	10.719	10.716	0.031	10.433	10.436	-0.025	9.945	9.949	-0.042
	85	10.507	10.503	0.041	10.243	10.245	-0.022	9.969	9.973	-0.037
	90	10.199	10.196	0.034	9.972	9.974	-0.017	9.917	9.920	-0.032

Graph 5: Ship Hull Righting Arm Comparison**Graph 6: Ship Hull Righting Arm Curve Variation**



Containership Hull:

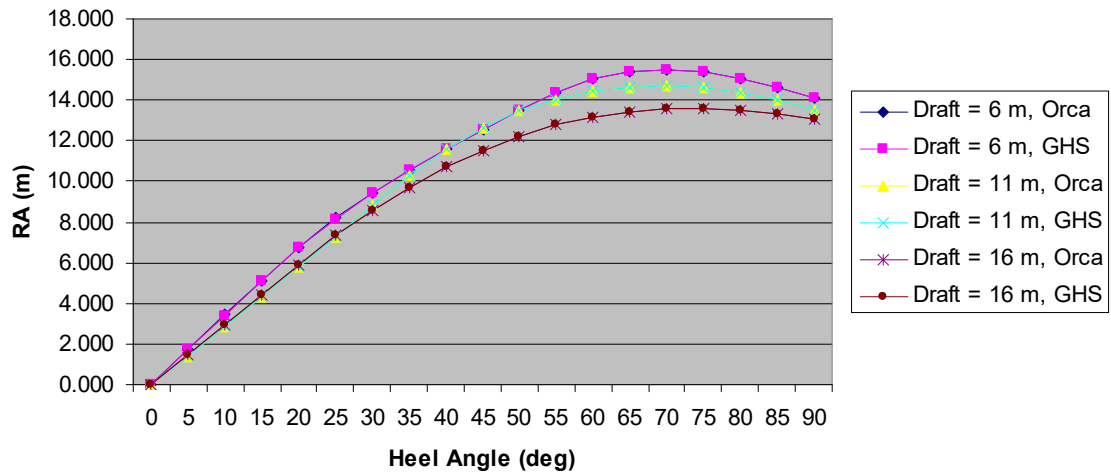
Figure 4: Containership Half Hull

Table 4: Containership Hydrostatics and Righting Arm Curve

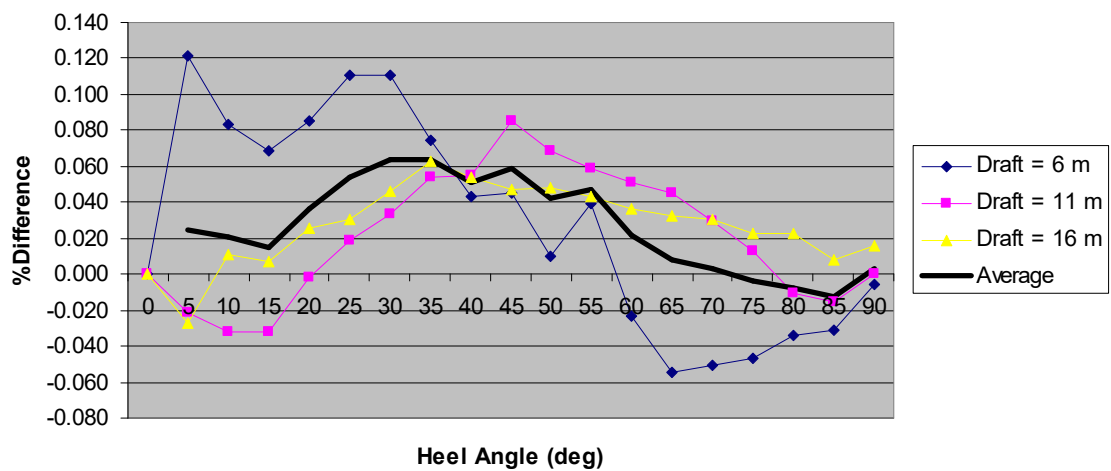
Mesh Density	0.7	Draft = 6 m			Draft = 11 m			Draft = 16 m		
		Orca	GHS	%Diff	Orca	GHS	%Diff	Orca	GHS	%Diff
Disp	t	37,091	37,097	0.017	75,612	75,622	0.014	121,952	121,928	0.020
LCB	m	134.43	134.40	0.020	136.30	136.36	0.045	140.80	140.80	0.004
VCB	m	3.25	3.249	0.094	5.96	5.954	0.060	8.84	8.840	0.041
WSA	m ²	8,884	8,904	0.216	12,227	12,264	0.300	15,846	15,917	0.443
Awp	m ²	7,029	7,036	0.098	8,224	8,211	0.165	9,494	9,498	0.036
LCF	m	135.06	135.29	0.171	143.34	143.09	0.177	147.71	147.67	0.026
BMt	m	16.31	16.282	0.174	10.24	10.214	0.226	8.06	8.052	0.089
BMI	m	741.17	744.05	0.387	525.00	521.72	0.629	472.80	473.10	0.064
GMt	m	19.56	19.530	0.154	16.19	16.168	0.136	16.90	16.892	0.047
GMI	m	744.42	747.30	0.385	530.96	527.67	0.623	481.64	481.94	0.062
Cb		0.598	0.597	0.212	0.664	0.637	4.208	0.706	0.689	2.457
Cp		0.624	0.621	0.477	0.680	0.651	4.451	0.718	0.700	2.612
Cwp		0.698	0.697	0.141	0.815	0.779	4.607	0.902	0.880	2.521
Cx		0.959	0.962	0.331	0.976	0.97	0.641	0.983	0.98	0.286
Cvp		0.857	0.857	0.015	0.815	0.817	0.294	0.782	0.783	0.068
RA	m	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

5	1.708	1.706	0.121	1.416	1.416	-0.02 2	1.475	1.475	-0.02 7
10	3.421	3.418	0.084	2.845	2.846	-0.03 2	2.950	2.950	0.011
15	5.128	5.124	0.069	4.295	4.296	-0.03 2	4.427	4.427	0.007
20	6.748	6.742	0.085	5.770	5.770	-0.00 2	5.908	5.907	0.025
25	8.184	8.175	0.111	7.278	7.277	0.019	7.339	7.337	0.031
30	9.440	9.430	0.110	8.803	8.800	0.034	8.603	8.599	0.046
35	10.569	10.561	0.074	10.281	10.275	0.054	9.725	9.719	0.063
40	11.610	11.605	0.043	11.615	11.609	0.055	10.711	10.705	0.054
45	12.590	12.584	0.045	12.674	12.663	0.085	11.551	11.546	0.047
50	13.530	13.529	0.010	13.473	13.464	0.069	12.239	12.233	0.048
55	14.389	14.383	0.039	14.050	14.042	0.059	12.779	12.773	0.043
60	15.019	15.022	-0.02 3	14.435	14.428	0.051	13.179	13.174	0.036
65	15.365	15.373	-0.05 5	14.650	14.643	0.046	13.447	13.443	0.032
70	15.469	15.477	-0.05 1	14.707	14.703	0.030	13.591	13.587	0.030
75	15.369	15.376	-0.04 7	14.617	14.615	0.013	13.616	13.613	0.023
80	15.092	15.097	-0.03 4	14.384	14.386	-0.01 1	13.529	13.526	0.022
85	14.656	14.661	-0.03 1	14.016	14.018	-0.01 5	13.335	13.334	0.008
90	14.085	14.086	-0.00 6	13.522	13.522	0.000	13.044	13.042	0.016

Graph 7: Containership Hull Righting Arm Comparison



Graph 8: Containership Hull Righting Arm Curve Variation



Part



20 OrcaCommandReference

Click on the links below to go to more information on the commands.

Command	Scriptable?
OrcaAbout: Displays a dialog with version information, as well as the status of your license.	
OrcaAssignWeightCost ⁴⁷⁰	Yes
OrcaCreateCfdRender ⁴³¹	Yes
OrcaCreateCfdReport ⁴²⁵	
OrcaCreateFloatPlane ²⁶⁴	
OrcaCreateFoil ¹⁸⁹	
OrcaCreateLinesDrawing ²¹⁶	
OrcaCreatePlaningHull ⁹⁸	Yes
OrcaCreatePlate ¹²¹	Yes
OrcaCreateRib ⁹⁸	Yes
OrcaCreateSailboat ⁹⁸	Yes
OrcaCreateShipHull ⁹⁸	Yes
OrcaCreateStrake ²⁰⁹	
OrcaCreateWeightCostPoint ⁴⁸¹	Yes
OrcaCrossCurves ²⁹¹	Yes
OrcaDefineDesignSimulation ¹³²	Yes
OrcaEditPlane ¹⁹³	Yes
OrcaExportCurves ²²⁷	Yes
OrcaExportMeshes: exports a mesh in a PreCal (.geo) format	Yes
OrcaExportStockMaterialLibrary ⁴⁶⁸	
OrcaHelp ⁸	Yes
OrcaHoltropAnalysis ³⁵⁹	Yes
OrcaHullAssistant ¹⁷⁵	
OrcaHydrostatics ²⁴⁷	Yes

OrcaInsertChine ²⁰⁷	Yes
OrcaInsertNet ¹⁹⁵	Yes
OrcaLayout ⁸⁴	Yes
OrcaLicense ⁴⁹⁵	Yes
OrcaManageHeelingArms ³³⁸	
OrcaManageStabilityCriteria ³²⁶	
OrcaManageStockMaterials ⁴⁶⁶	
OrcaManageWeightCost ⁴⁷⁵	
OrcaMergeStockMaterialLibrary ⁴⁶⁸	Yes
OrcaMove ¹²²	Yes
OrcaNavCadAnalysis ³⁶⁸	
OrcaOffsetTable ²²⁴	Yes
OrcaPlaningAnalysis ³⁵⁰	Yes
OrcaPlayStabilitySimulation ¹³²	Yes
OrcaPointsOfInterest ¹⁴⁴	Yes
OrcaPointsOn ¹²¹	Yes
OrcaProperties ⁷⁷	Yes
OrcaRemoveNet ¹⁹⁵	
OrcaReportWeightAndCost ⁴⁷⁸	Yes
OrcaResetModelID	
OrcaSections ²³⁶	Yes
OrcaSectionsRecompute ²⁴¹	Yes
OrcaSelWeightCost ⁴⁷⁴	Yes
OrcaShowSection ²⁴³	Yes
OrcaShowTree ¹⁶⁶	Yes
OrcaSimericsAnalysis ³⁷¹	
OrcaStabilityCriteria ³²²	
OrcaSTIXCriteria	
OrcaStraightenPoints ¹⁹⁹	

556

Orca3D

OrcaViewports ⁹⁶	Yes
OrcaWrapCorner ²¹³	Yes

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