Orca3D™

Leveraging the power of Rhino for the naval architect

Orca3D

User Manual

Version 1.00

Table of Contents

Part I

1 Welcome to Orca3D 1.00

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 is an entirely new program, 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 II

2 Latest Updates

Updates and changes to Orca3D will be described here, listed by release number. You can also read the Release Notes, which are included as part of the installation, to see a complete history of the releases and changes to Orca3D.

2.1 Version 1.0

WIP 4.1 (September 2, 2008)

2.2 Release Notes

Orca3D Release Notes

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

Orca3D Requirements

- Rhino Version 4, SR 3 or higher
- Hardware: See Rhino hardware requirements (http://www.rhino3d.com/4/systemrequirements.htm)
- Operating Systems tested: Windows XP , Vista
- Operating Systems not tested: Windows XP 64-bit, 2000
- Operating Systems ***not supported***: Windows ME, 98, 95, NT
- Mac: The Intel Mac with Bootcamp or Parallels ***has not*** been tested
- Microsoft .NET Framework 2.0 (the Orca3D installation will install it if it is not already on your computer)
- Microsoft Report Viewer Redistributable 2008 (the Orca3D installation will install it if it is not already on your computer)
- Valid license key (without this, Orca3D will operate as a 30-day fully functional evaluation copy, not required for WIP releases)

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. This may show up as nonsensical results in either hydrostatics or resistance calculations (e.g., LCB=0 when it shouldn't be).

- **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 and 3D 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 mouse wheel 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**: Verious speeling errers hav bin fixd.
- **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 III

3 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 8 for details on the latest features.
- See Getting help 19 for details on using this help and getting more information about Orca3D.
- Then work through the Quick Start Tutorials 31 to familiarize yourself with using Orca3D.

3.1 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 31.

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 you 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.

See also:

Quick Start Tutorial 31

3.2 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. Th 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...

3.3 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 17 and Quick Start Tutorials 31 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 139 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 31 in the help for some basic tutorials to get you started with using Orca3D.
- You will find some of the models used in the tutorials in the /Tutorials folder.

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 on our website:

http://www.orca3d.com/support/support.htm

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 21

3.4 Online information and links

Orca3D Blog and RSS Newsfeed:

News about Orca3D is posted on our website, but you may also receive the latest news at our blog, and you can automatically receive updates via an RSS feed from the blog:

http://www.orca3d.blogspot.com/

The Orca3D online users' forum:

Registration for the forum is free. In addition to sections on all aspects of using Orca3D and related products there are also tutorials, tips and tricks, templates and more. Discussion is lively and the other users are helpful and supportive.

Please note that you must register if you want to post in the forum. To do this you must choose a user name and password.

Forum address:

This address takes you to the main forum portal page:

http://www.orca3d.com/forum

Video Tutorials:

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

http://www.orca3d.com/support/support_videos.htm

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 19

3.5 How to buy Orca3D

You can buy Orca3D 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.

Direct order link:

http://www.orca3d.com/order/order.htm

Orca3D home page:

http://www.orca3d.com

Email support:

support@orca3d.com

Postal mail and fax:

DRS C3 Systems, LLC
Advanced Technology Center
149 Log Canoe Circle
Stevensville, MD 21666 USA
Fax: +1 410-643-5370

Part IV

4 Properties & Units

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

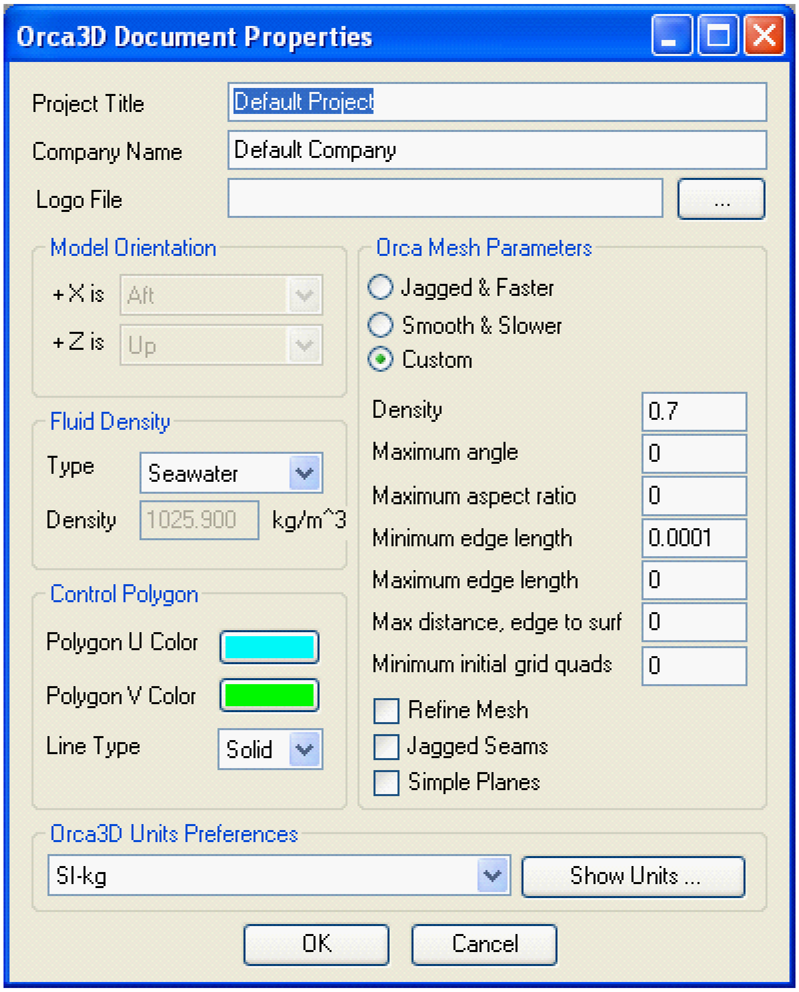
In the Orca3D Document Properties you can edit several different items.

- Information about yourself and your project.
- The orientation of the model.
- The properties of the water the model is supposed to be used in.
- Orca Mesh properties, and control polygon settings
- Orca Units

Toolbar	
Menu	**Orca3D > Properties**
Command	**OrcaProperties**

1. Start the command with the toolbar icon, menu selection or keyboard command.

2. The Orca3D Document Properties Dialog Box will appear:



3. Type the Project Title and Company Name that you wish Orca3D to use. Both these items are used for the report generated for hydrostatics and the lines drawing.
4. The line titled Logo File is where the path to the logo file you want used in the hydrostatics report appears. The file you wish to use must either be in bitmap or JPEG format.
   a. You may type the path to the file into the text box.
   b. A more convenient method is to click the button to the right labeled " … " and browse to the location of the logo file.

Model Orientation

5. This feature has not yet been implemented. When complete, you will select the coordinate that corresponds to "forward" in your model.
6. This feature has not yet been implemented. When complete, you will select the coordinate that corresponds to "up" in your model.

Fluid Density

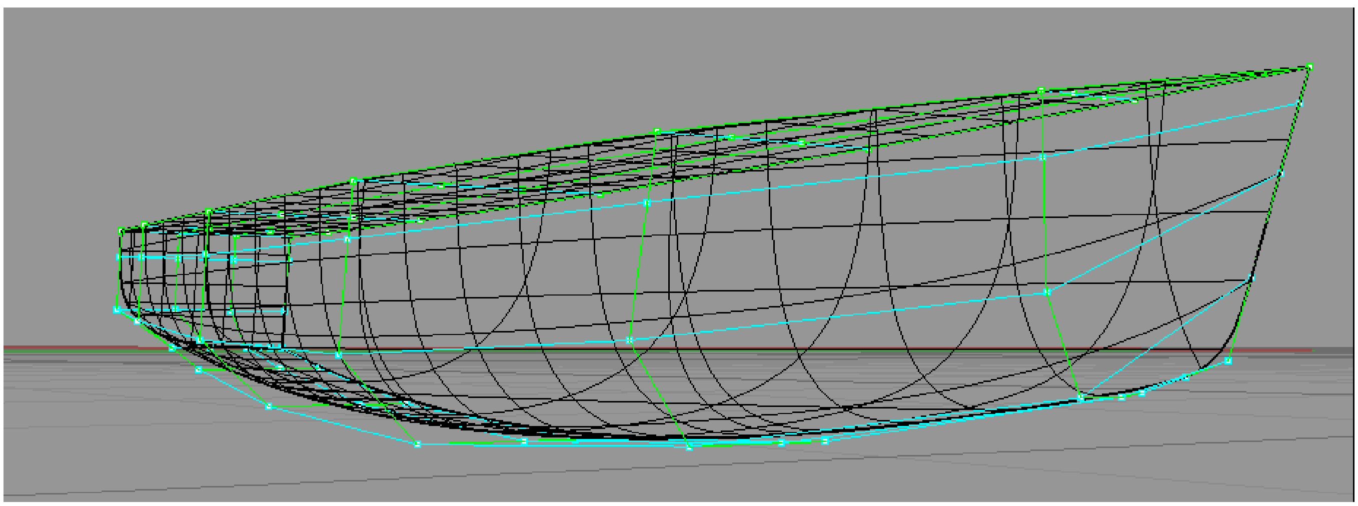
7. Select either Seawater, Freshwater, or custom from the drop down menu. Orca will use this fluid property to calculate the hydrostatics of your model.
   a. If you choose either seawater or freshwater, the density is displayed below the

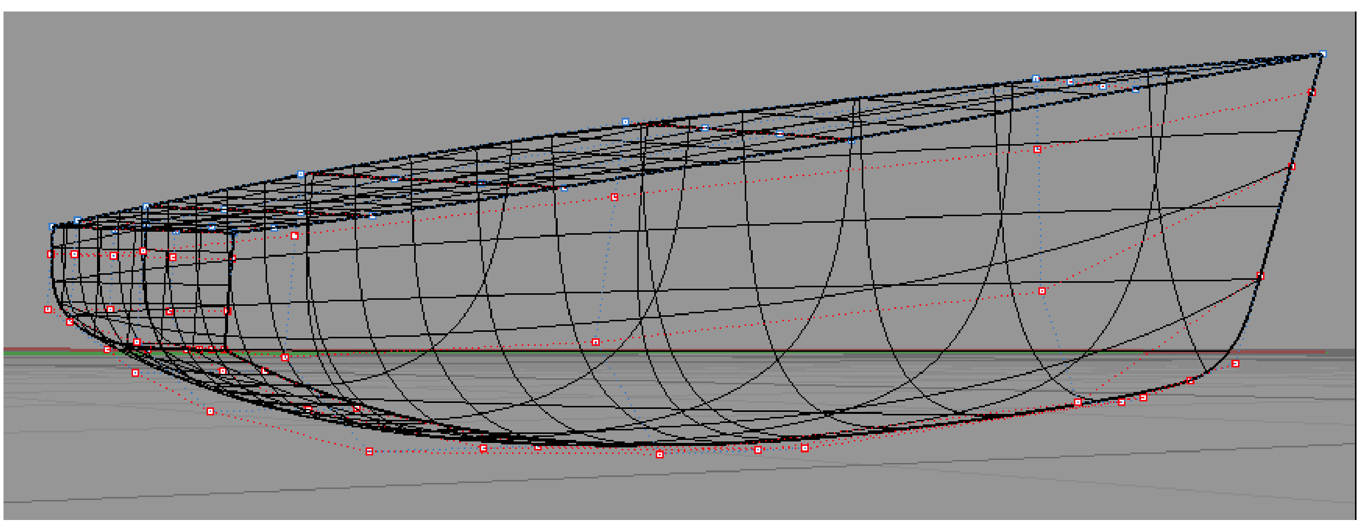
choice.

b. If you choose custom, you must enter your desired density into the text box with the indicated units.

Control Polygon

8. Orca3D has its own control polygon system 34, which is similar to the control points maintained inside Rhino. If these polygons are edited, the hull and sections 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.
   a. 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.
   b. 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.

9. 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.
10. 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.
11. Select whether you wish the polygons to be drawn with a solid line or a dotted line.

Orca Mesh Parameters

12. Edit the Orca Mesh Parameters to change how Rhino computes the Orca mesh for use in hydrostatics calculations.
13. You can either choose to have the mesh as jagged and faster, smooth and slower, or custom.
    a. For more information on the properties listed when custom is selected, go to the Rhino Help and navigate to Rhinoceros Help > Document Properties > Mesh.

Orca3D Units Preferences

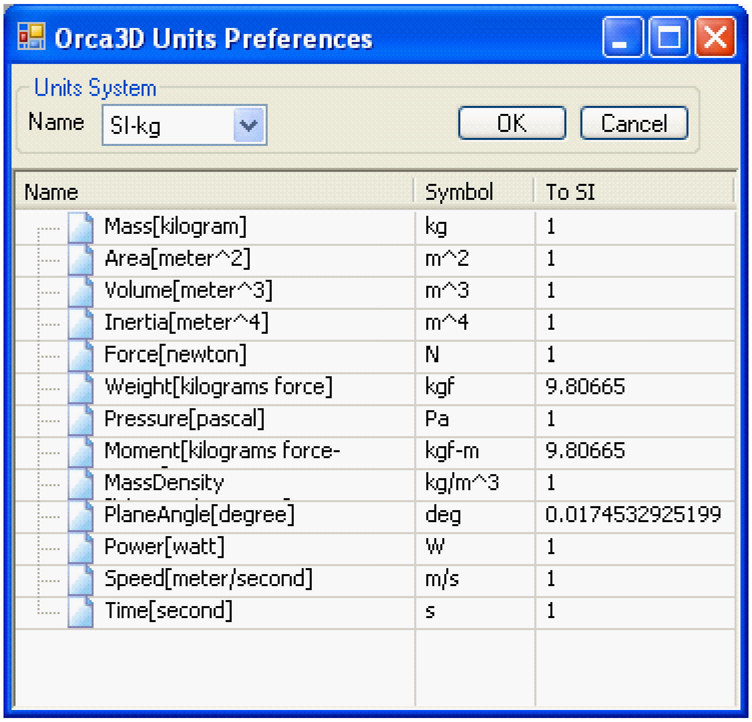
14. Select the unit system that you wish Orca3D to use.
    a. The Length unit is independent of Orca3D and is managed and maintained by Rhino. If you wish to change the Length unit, this must be done in Rhino's settings.
    b. A note on tolerance: as with the Length unit, the tolerance value is part 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 >= 10 x 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)

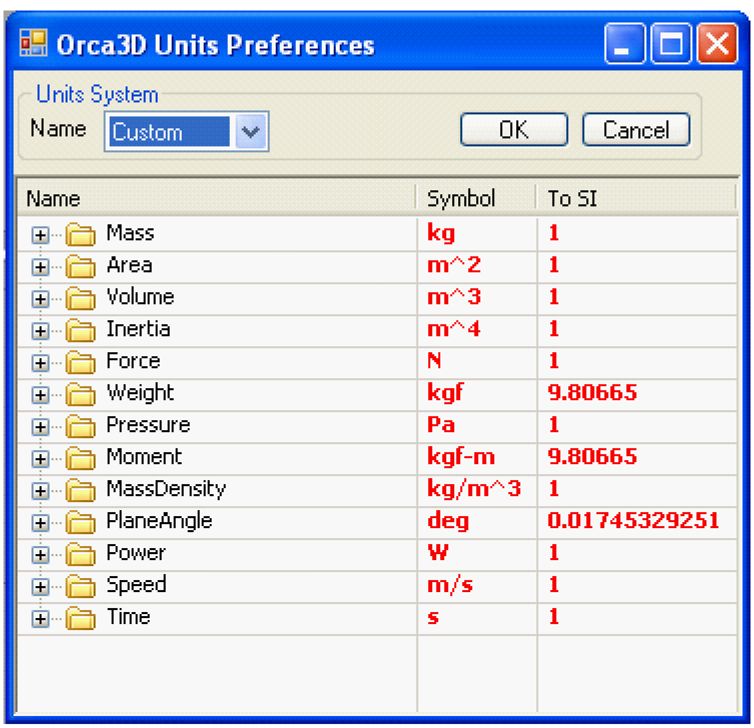
    This implies that a typical vessel, designed in meters, could have the absolute tolerance set between 1 millimeter and 1 centimeter (0.001 to 0.01). If your model will have small features, such as fillets on the order of 1 centimeter in size, the tolerance should be closer to 0.001. If the vessel is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

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

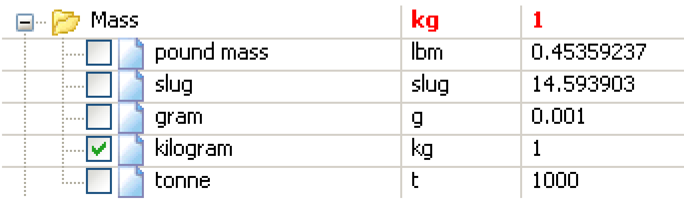


a. You can select the different unit systems at the top and see which units are being used for each unit type. To the right of the unit is the abbreviation for the unit, and the conversion factor to SI units.

17. If you select custom as the Unit System, the dialog box changes as follows:



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



Mass	kg	1
pound mass	lbm	0.45359237
slug	slug	14.593903
gram	g	0.001
kilogram	kg	1
tonne	t	1000

   c. 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.
   d. Customize each unit type at your discretion to fully customize the Unit System.

18. Select OK when finished editing the units.
19. Select OK when finished editing the Orca3D Document Properties.

Part V

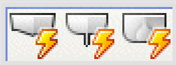
5 Quick Start Tutorials

The tutorials in this section 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 in the tutorials please refer to the sections that cover the individual modules.

5.1 Hull Assistants

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

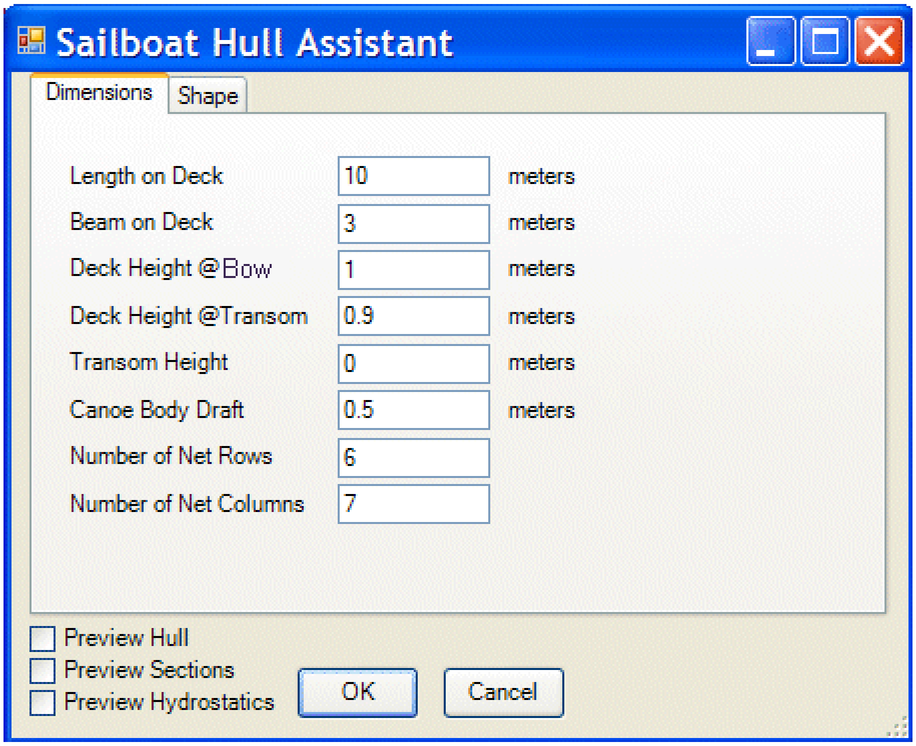
Toolbar	
Menu	**Orca3D > Hull Assistants > Planing, Sailboat, or Ship**
Command	**OrcaCreatePlaningHull** **OrcaCreateSailboat** **OrcaCreateShipHull**

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.

There are three Hull Assistants:

- Planing Hull: double chine hull
- Sailboat: moderate displacement, round-bilge hull
- Ship: large commercial-type ship (no bulb)

1. Begin by selecting one of the Hull Assistants from the **Orca3D > Hull Assistants** menu, or from the toolbar (note that the toolbar icons are "flyout" icons; if you click and hold on the Assistant icon, you will see a new toolbar showing all three Assistant icons). The appropriate dialog will be shown:



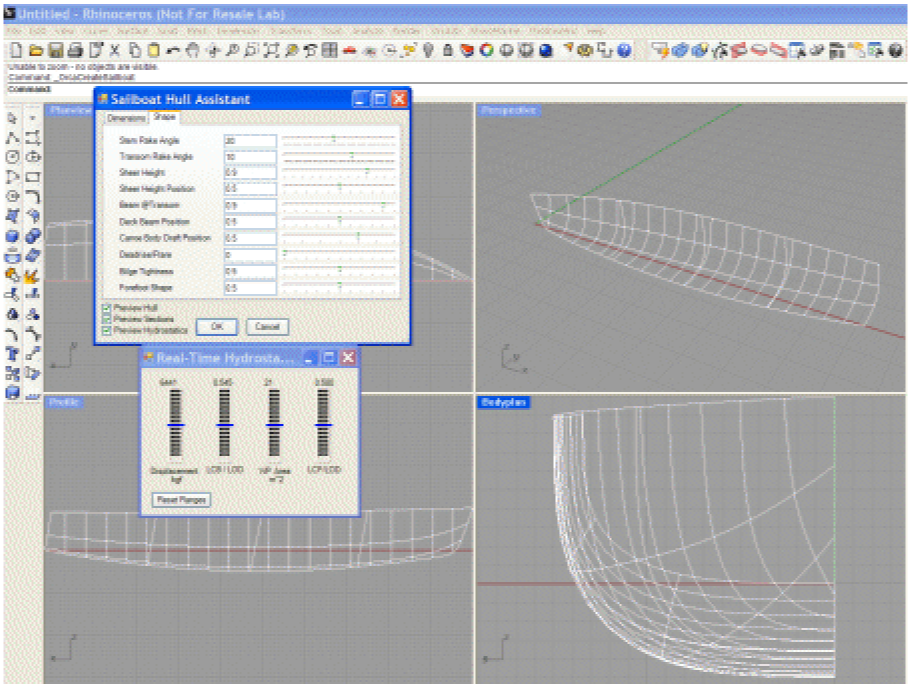
Note that there may be more than one tab in the dialog

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. 21 evenly spaced stations will be shown.

4. If you'd like to see the Hydrostatics as you preview, check the Preview Hydrostatics box.

5. After all of the parameters are set, click OK.



If you want to edit the hull, 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 option in the dialog that defines the Design Hydrostatics 42 condition.

See also:

Hull Design 72

5.2 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 72 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 42, the hydrostatics will update in real-time as well.

Orca3D hull modeling tools include:

- Hull Assistants 31

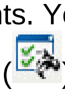
- Section Definition 38
- Design Hydrostatics 42
- Orca Control Points 34
- Orca3D Move Control 34
- Real-Time Hydrostatics
- Corner Continuity tool (to create a smooth forefoot, for example)
- Lines Plans
- Exporting Curves for other programs (IDF and PIAS)

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.

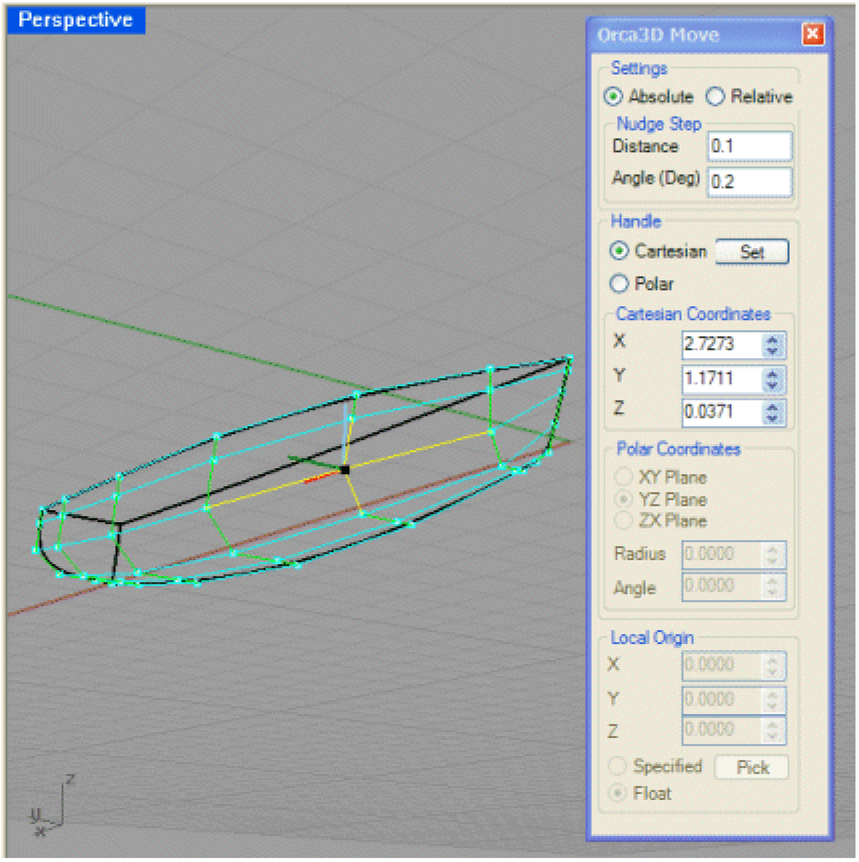
3. The control points for the surface(s) will be shown. Orca control points, and the lines that connect them, are drawn differently than the standard Rhino control points. You may control the color of the lines in the control polygon in the Orca Properties dialog (). By default, control lines in the 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 box in the Define Design Condition 42 dialog, you will also see a window showing the hydrostatics data updating.

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 allows you to easily enter the coordinates of an Orca Control Point 34 (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 34, 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

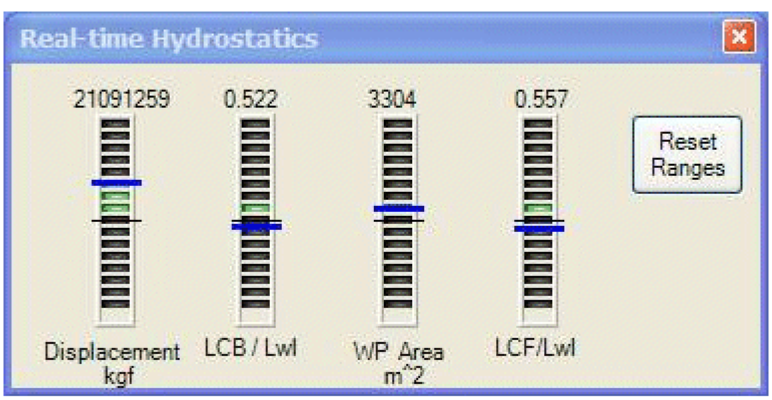
3. Click on the control point that has the Y value that you want. This is now the Local Origin (you may also simply enter the X, Y, and Z values of the Local Origin)

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.

Real-Time Hydrostatics

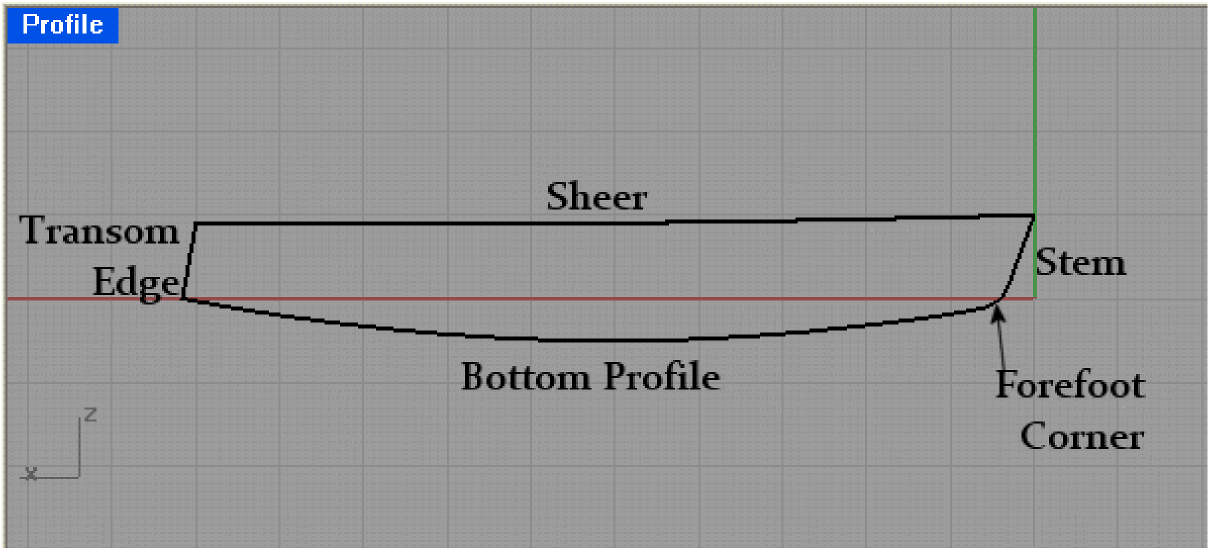
As Orca control points are moved, the program can compute and display various hydrostatic properties of your hull . To enable this function, open the Design Hydrostatics dialog (**Orca3D > Stability > Define Design Condition**), and check the Real-Time Hydrostatics box. A window showing the values of Displacement, LCB/Lwl (longitudinal center of buoyancy divided by waterline length), Waterplane Area, and LCF/Lwl (longitudinal center of flotation divided by waterline length) will be displayed:



As 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 to red at 5%. The sliders can be reset at any time to the current value by clicking on the "Reset Ranges" button.

Corner Continuity

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 Continuity** 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 ( CornerU0V0=No  CornerU0V1=No  CornerU1V0=No  CornerU1V1=No ):
```

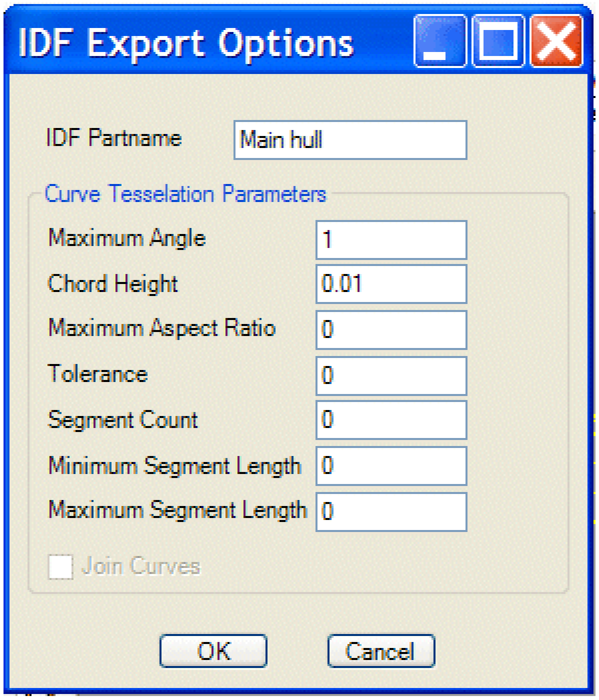
By clicking on any corner of the surface, its corresponding Corner will toggle between "No" and "Yes." Once you have selected the desired corner(s), hit Enter to complete the command. The corner control point will now be precisely located to create continuity at that corner.

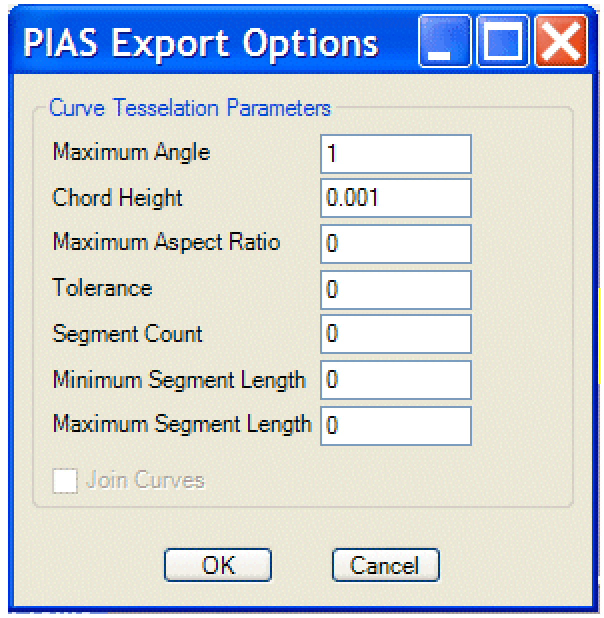
Lines Plans

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 72

5.3 Sections

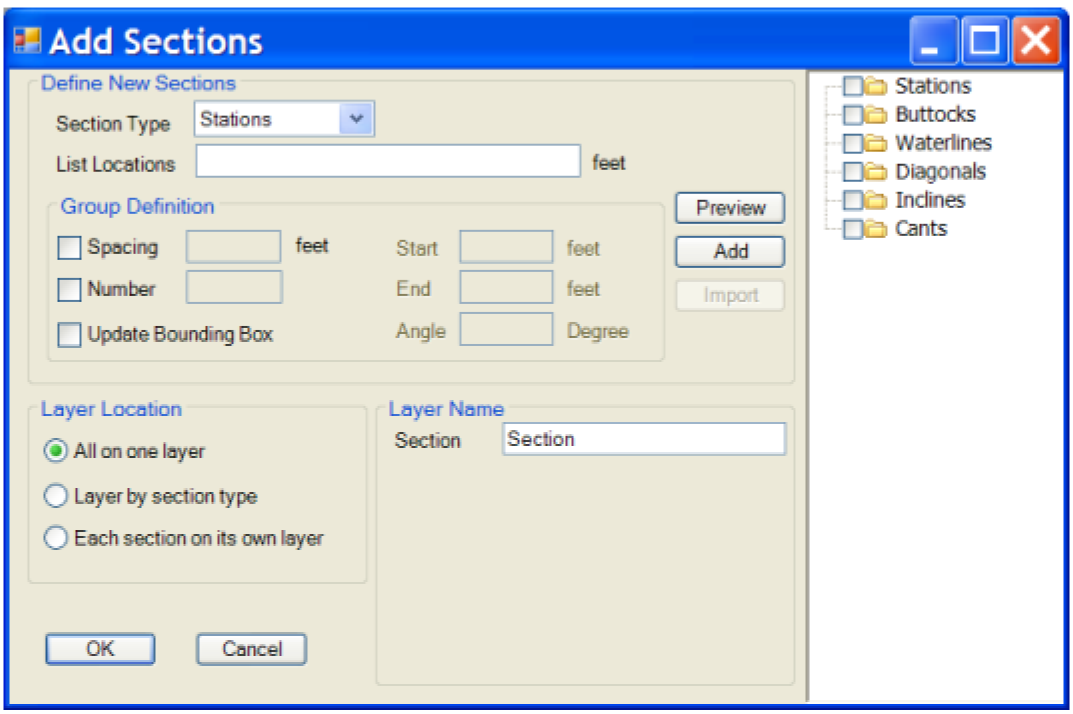
This tutorial shows you the basics of creating sections through your model in Orca3D. For more detailed instructions and background information see the Sections 95 section.

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 Orca3D Properties ().

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.
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 95

5.4 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 102 section.

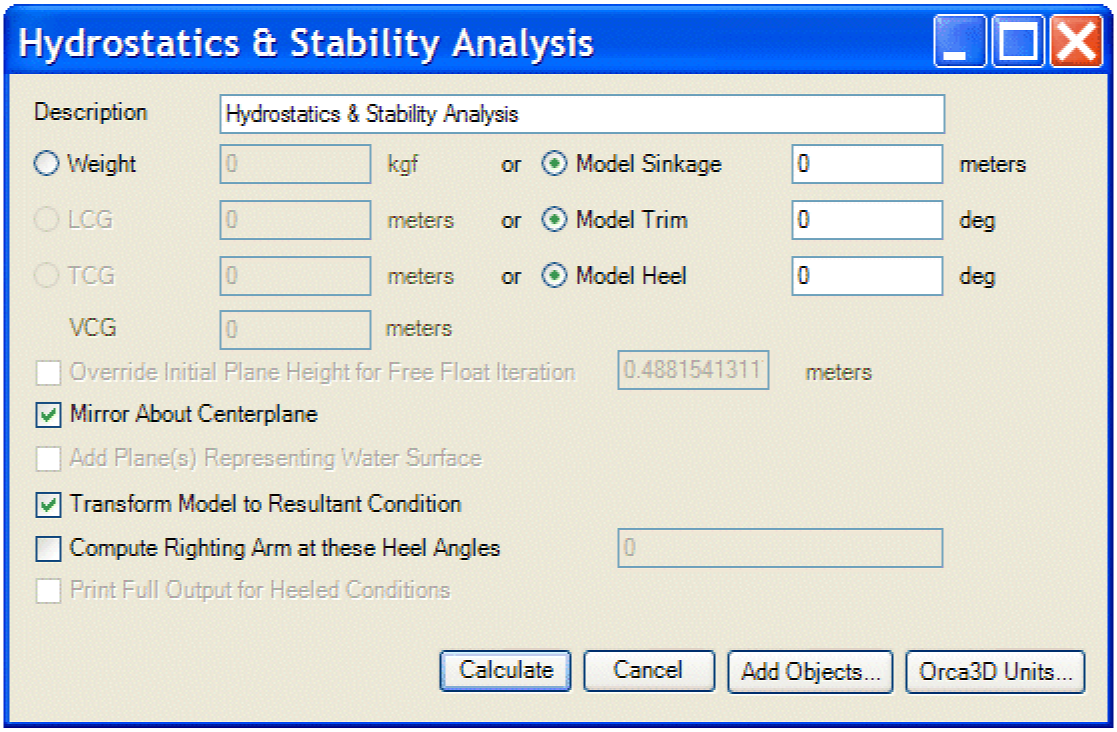
Toolbar	
Menu	**Orca3D > Stability > Compute Hydrostatics & Stability**
Command	**OrcaHydrostatics**

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.



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

or

1,2,...,5

The spacing implied by the first two numbers will be used until the last number is reached or exceeded. Note the commas before and after the ellipses.

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 as well.

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.

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.***

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 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.

10. 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.

See also:

Hydrostatics & Stability 102

5.5 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 102 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** command, or the icon (), and set the values in the Orca Mesh Parameters section.

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

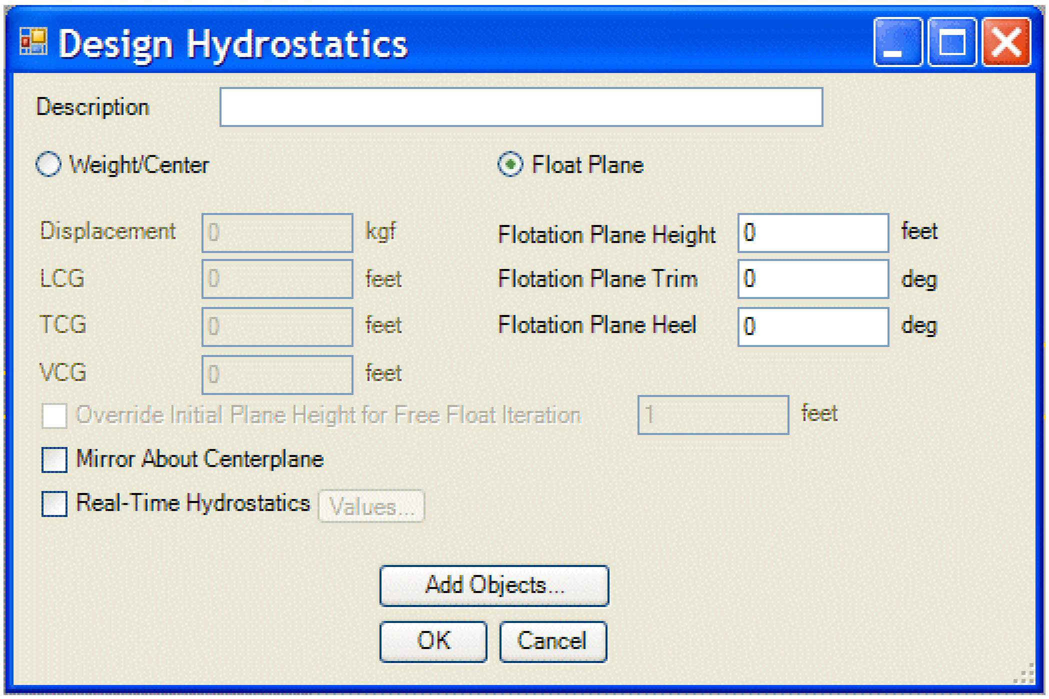
Orca3D can compute hydrostatics and stability in various combinations of waterplanes/ displacement and center of gravity/heel/trim, with a range of heel angles. However, while you are fairing a hull, you are usually just interested in the hydrostatics at the "design waterline," or at a particular displacement/center of gravity.

In Orca3D, there is 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.

To define the Design condition:

1. Select **Define Design Condition** from the **Orca3D > Stability** menu.

2. Select the surface(s) to be included in the calculations, and hit Enter. The following dialog will appear:



3. Select which mode you want: Weight/Center, or Flotation Plane.

4. If your model represents just one-half of the vessel, check "Mirror About Centerplane"

5. If you want to see hydrostatic values in real-time as you edit the hull, check the "Real-Time Hydrostatics" box.

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.

2. Select **Compute Design Hydrostatics** from the **Orca3D > Stability** menu, or click on the () icon on the toolbar (the icon is on a flyout toolbar with the Hydrostatics & Stability icon).

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:

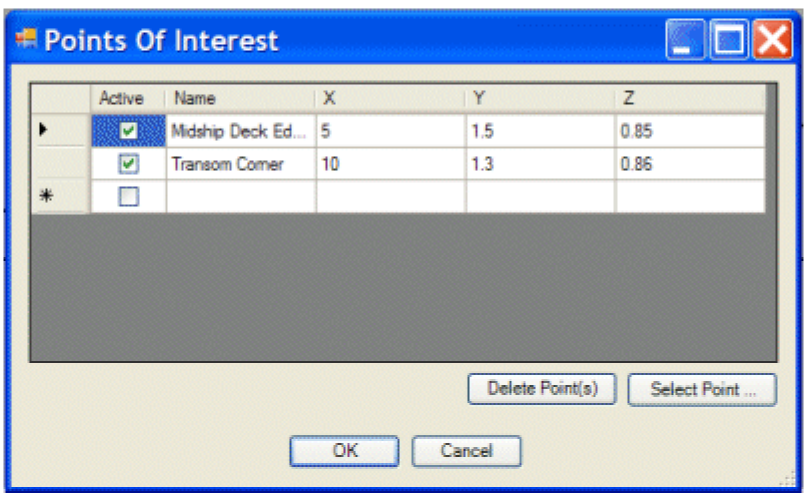
[Hydrostatics & Stability](102) 102

5.6 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:



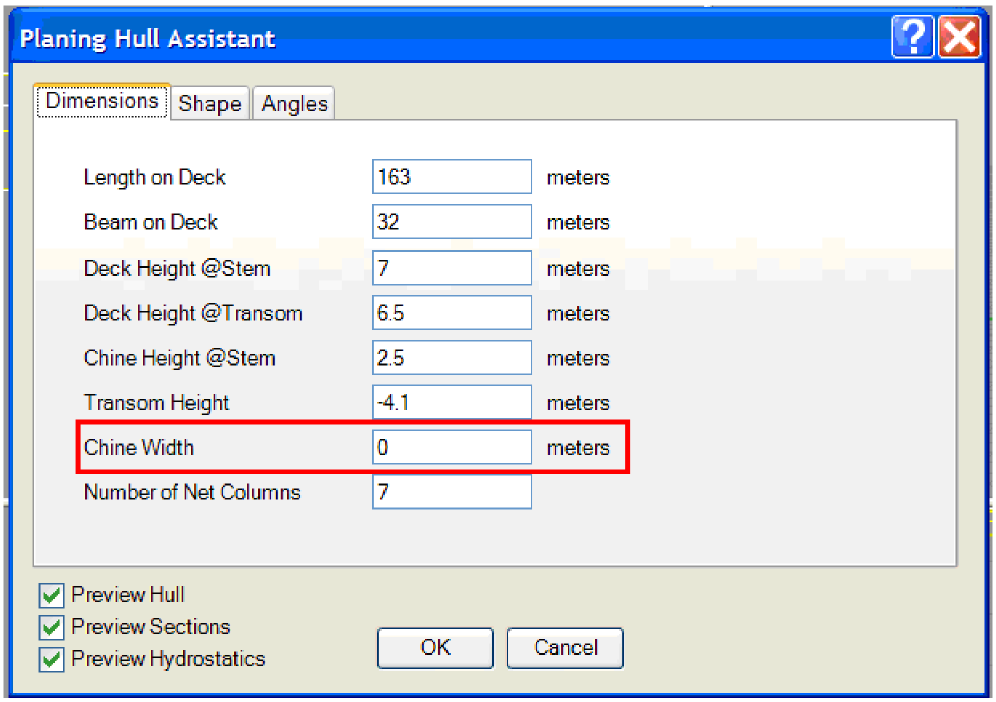
To enter a new POI, click in the Name field and enter a description of the POI. Enter the X, Y, and Z coordinates of the point. By checking the box in the Active column, you can determine whether the POI will be tracked and reported in the output. The POI's may be sorted by Name, X, Y, or Z by clicking 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 "Select Point" button, and click on the appropriate location in your model. You will then be able to enter the Name for that point.

5.7 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 meters.

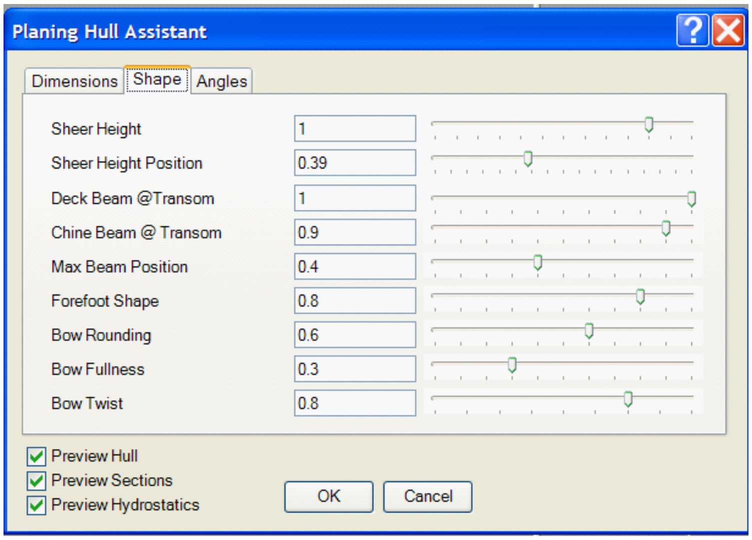


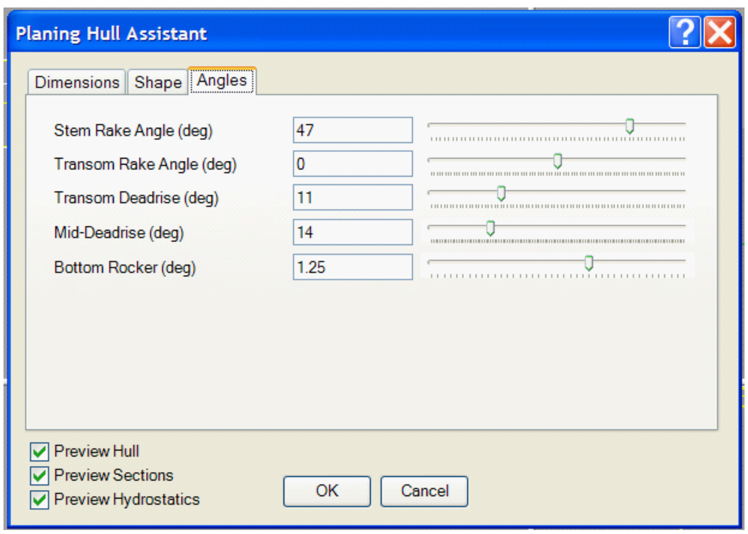
To get a good feel for our design, we'll select the *Preview Hull* check box as well as *Preview Hydrostatics* in the Planing Hull Assistant dialog box. The *Preview Sections* check box allows you to see 21 evenly spaced stations in the previewed hull.

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.

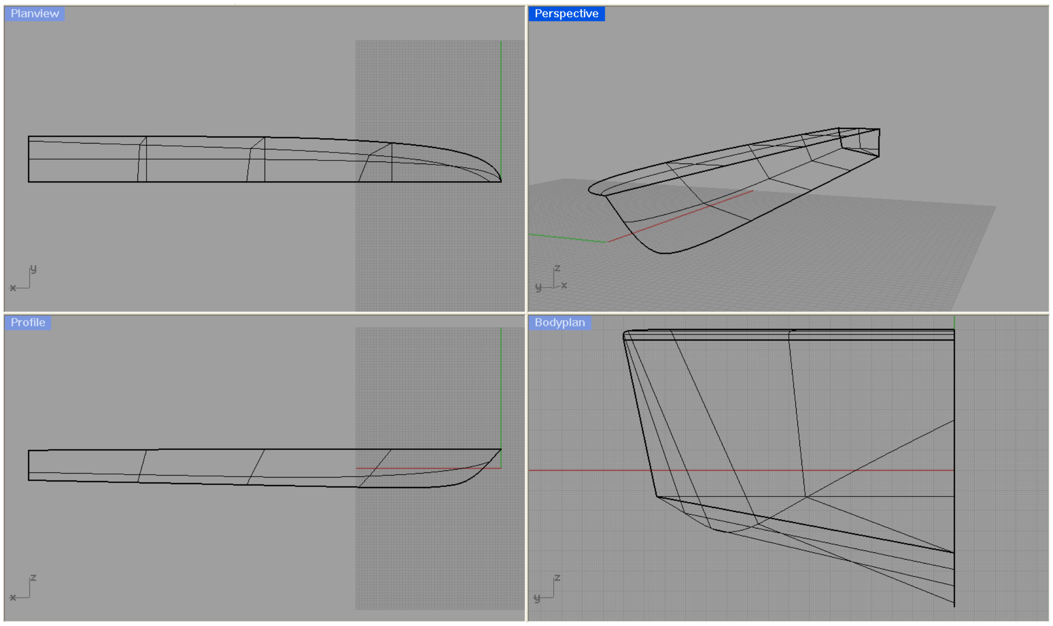
The preview hydrostatics are based on the waterline being located at the Z = 0 plane. If you wish to increase the draft of your vessel, you will want to increase the transom height. This height is essentially the draft aft of your vessel.

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

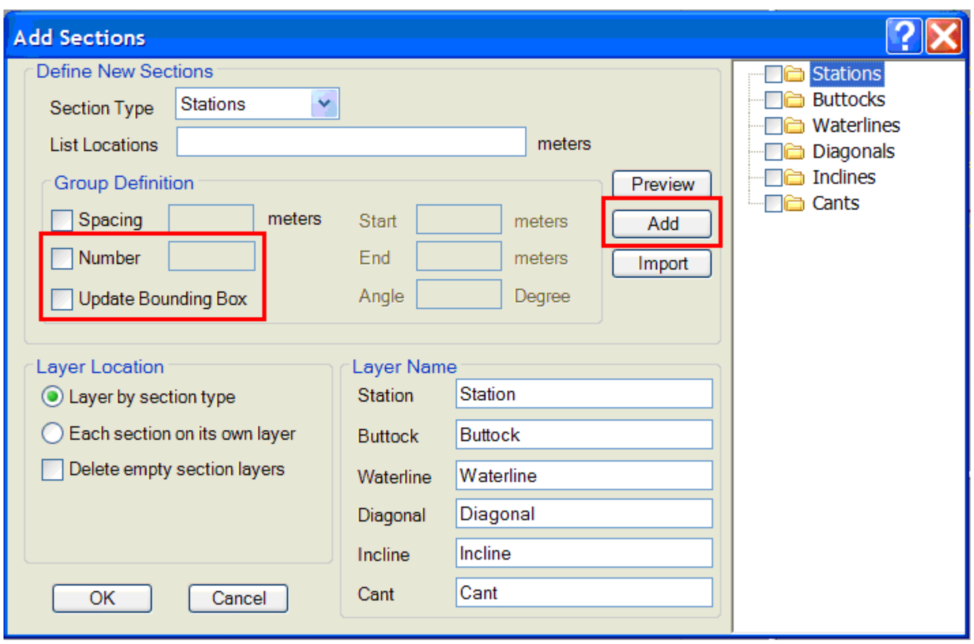




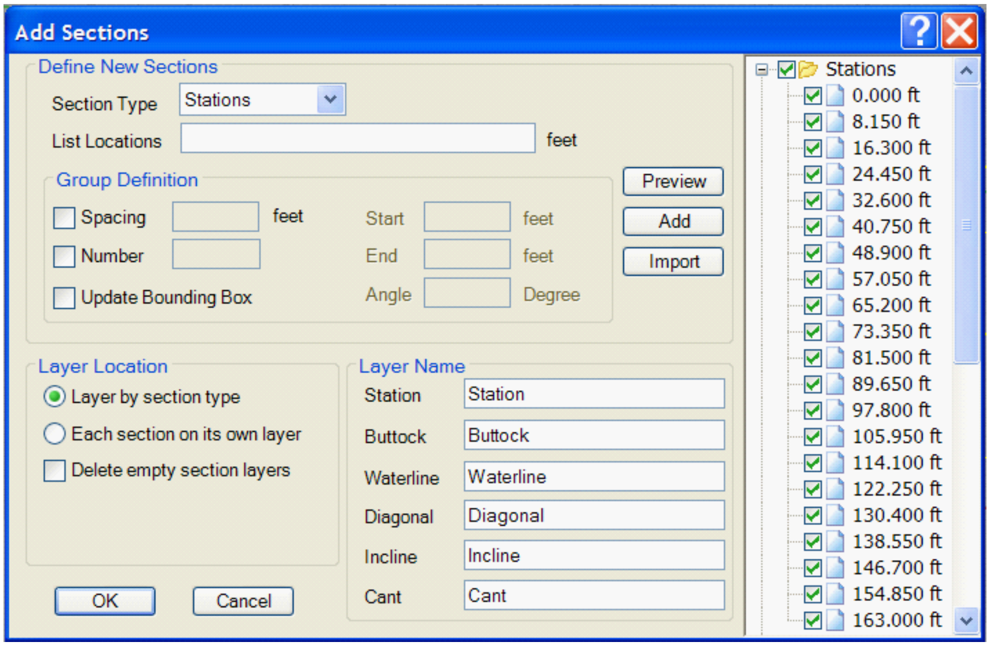
Our basic hull shape is now defined and ready to be finely tuned using OrcaMove.



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 .

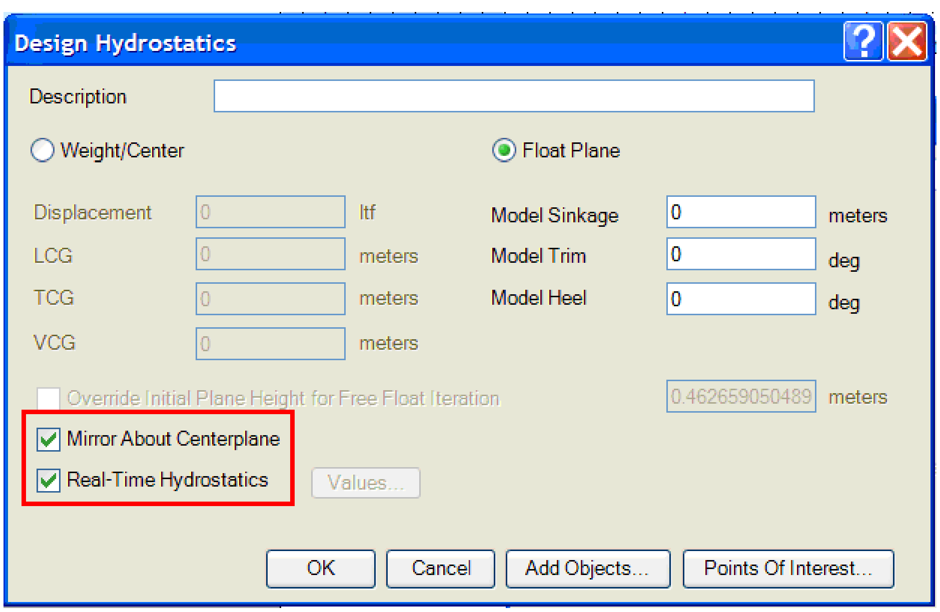


We can now add stations, buttocks, waterlines, diagonals, inclines, and cants. At this time, we will just add stations to our hull. The section type is already selected on *Stations,* so next we will click the *Update Bounding Box* checkbox. This will automatically update the *Start* and *End* text boxes 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.



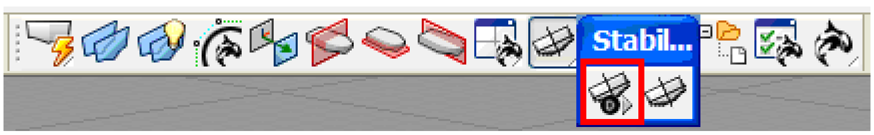
This same process can be used to add buttocks, waterlines, diagonals, inclines or cants.

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.

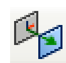


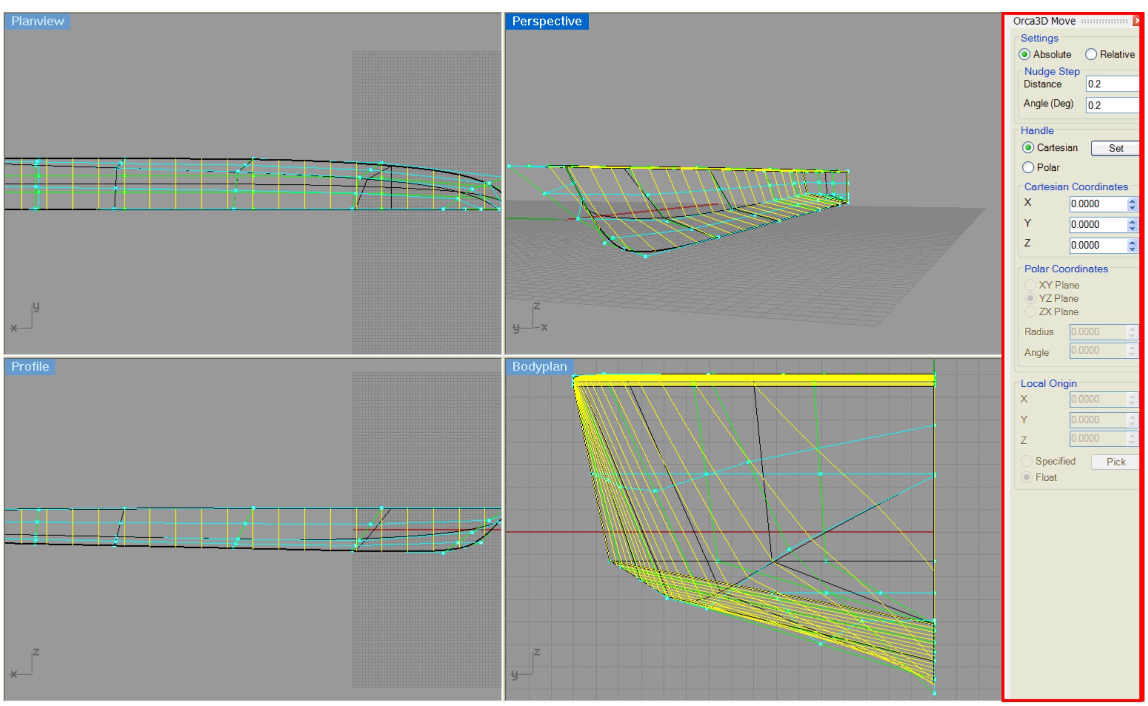
The Design Hydrostatics dialog opens and we can now define a description of this condition, for example “design waterline.” There are two options to define the model orientation: providing the displacement and hull centers of gravity or providing the model sinkage, trim and heel. We will select the float 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.

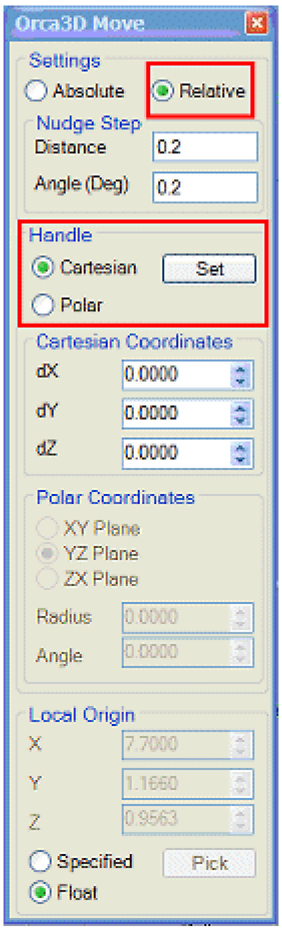
Orca3D Move can be initialized from the Orca3D Move icon . This will open the Orca3D Move dialog box on the right hand side of the screen.

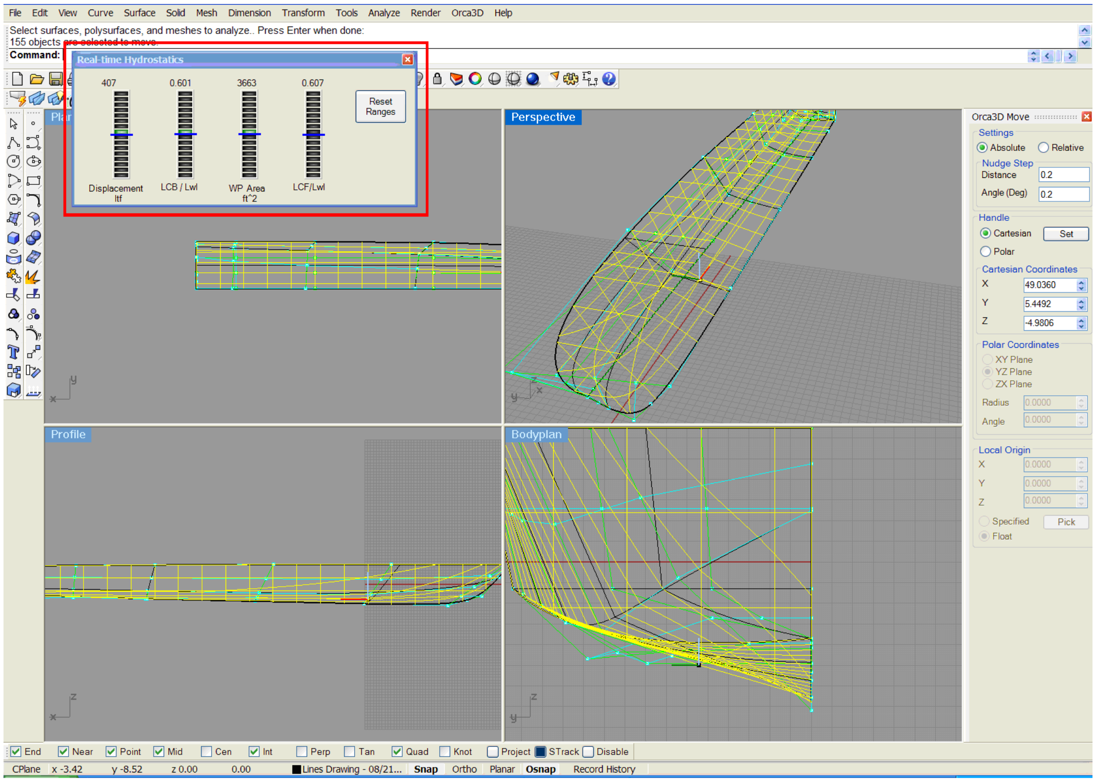


Now instead of creating stations and lofting surfaces through them, we are able to manipulate a parent hull and have the stations update automatically as the Orca3D control points are moved. These points can be moved in relative or absolute, and Cartesian or polar coordinates.

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.

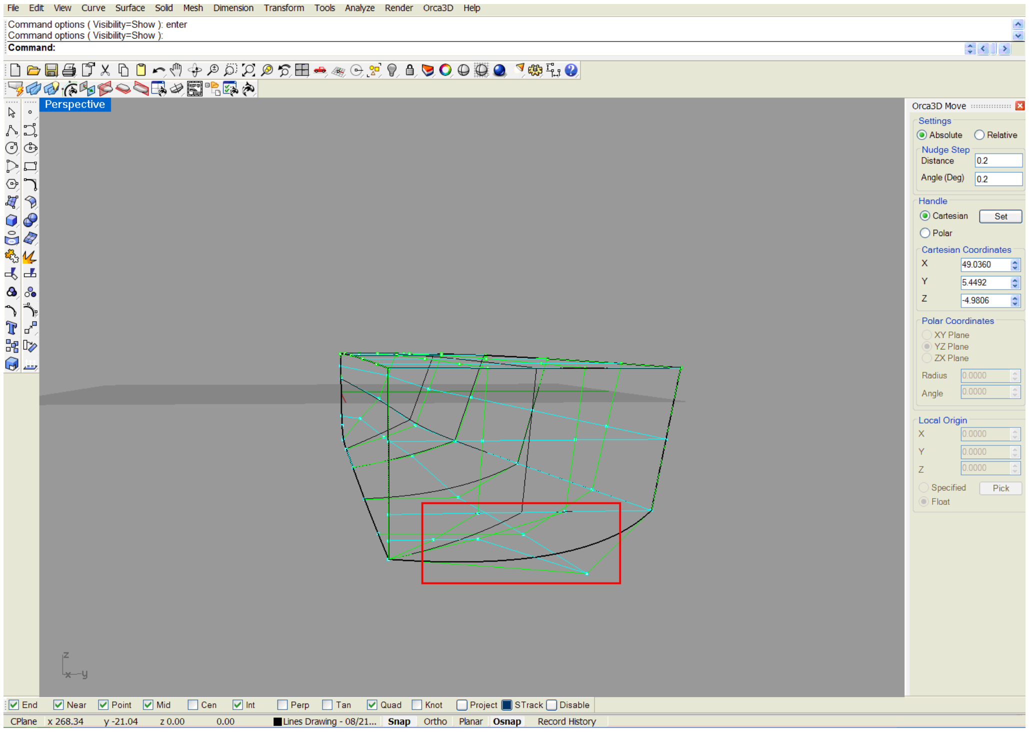
If Relative movement is selected, the Cartesian Coordinates values will be automatically set to 0 and the selected points will be moved the defined dX, dY, and dZ values from the handle.



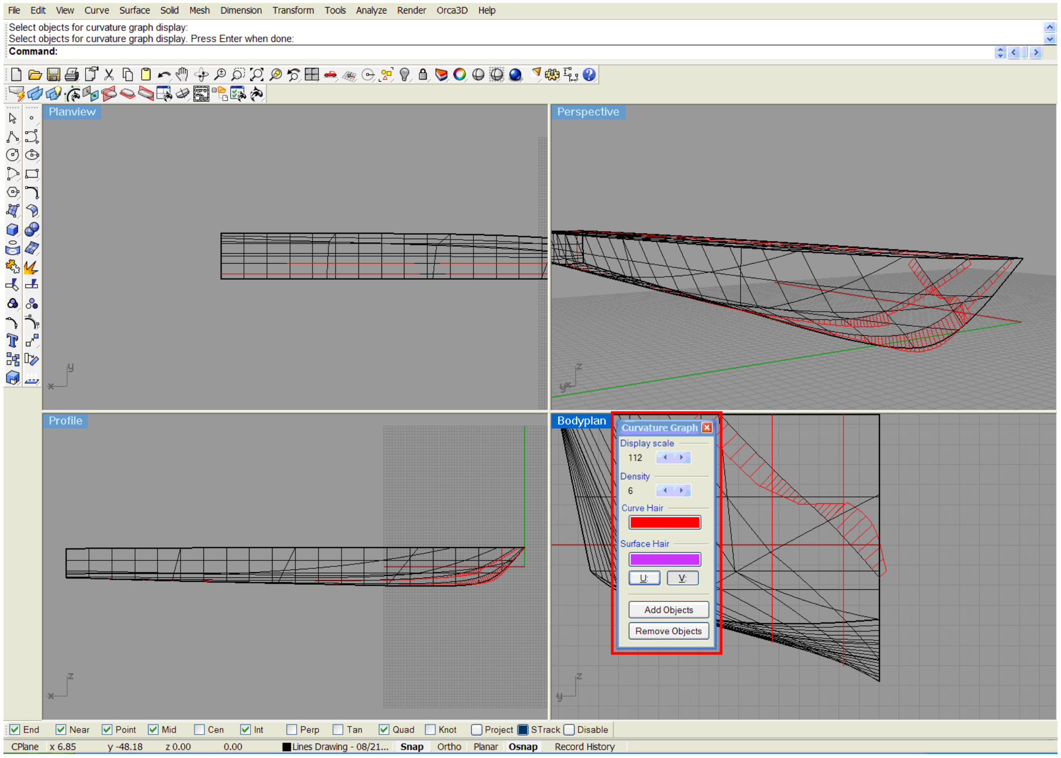


Imagine we plan to install an azimuthing thruster or water jets and want a relatively flat area in the aft portion of the hull bottom. We can use OrcaMove to manipulate control points in the desired region and "flatten" out the hull bottom.

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.

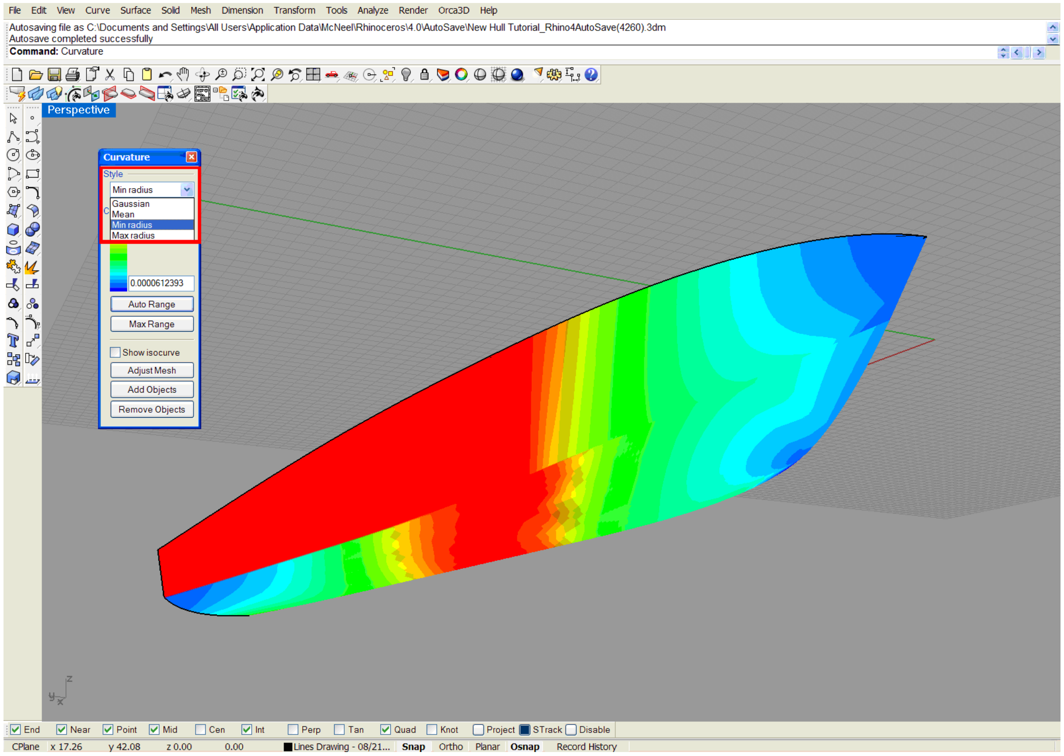


Once the hull is modeled as desired, the fairness of the hull can be evaluated using Rhino's curvature analysis functions. The first method is to plot a curvature graph for selected curves and surfaces. To do this, type the command: *CurvatureGraph* and press Enter. You can now select hull or section 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.*

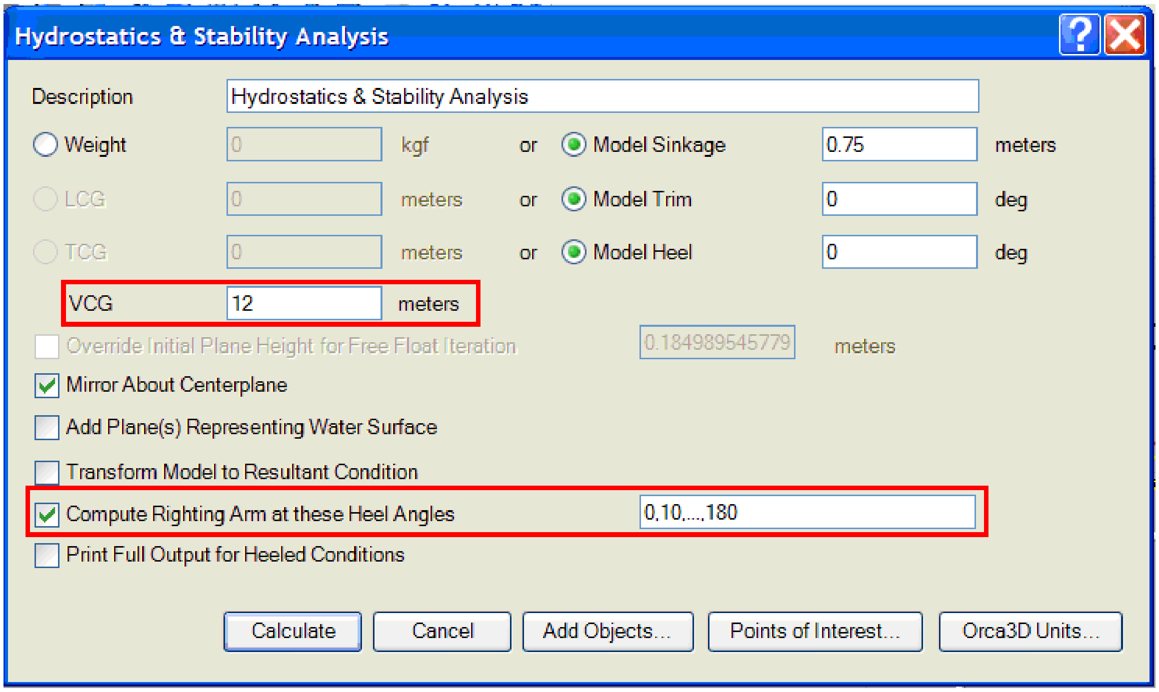
The second method for analyzing the fairness of the hull is a Curvature Analysis of the surfaces. This function can be run by typing the command: *CurvatureAnalysis*. You will be prompted to select the surface to analyze. We will select the hull surface and press Enter. The dialog box will open and allow 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.



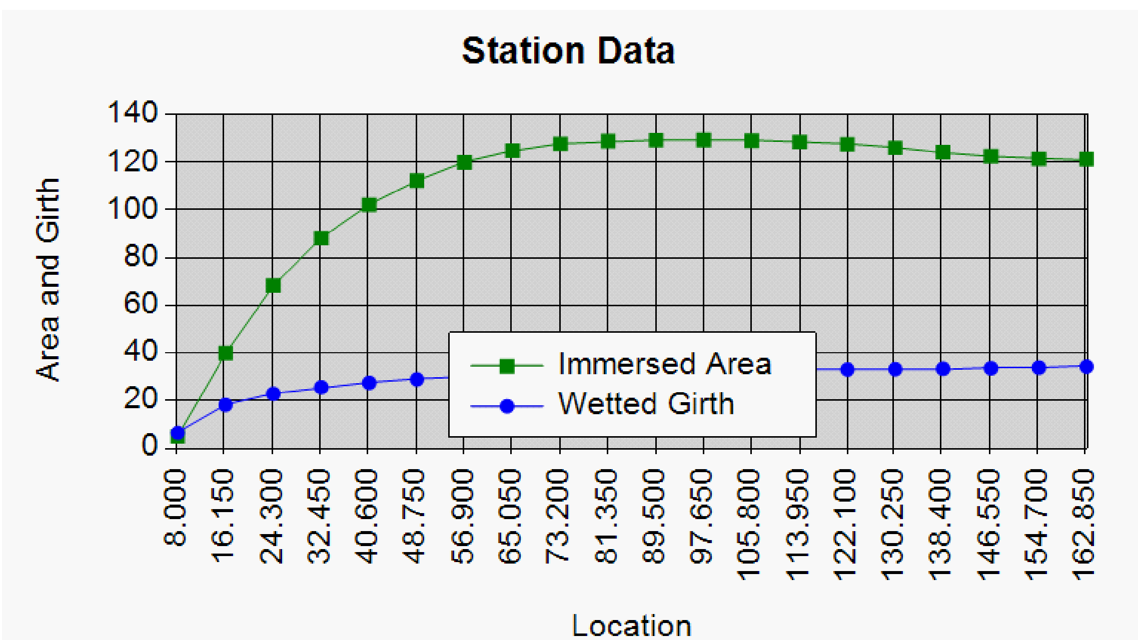
The hull can now be used to analyze additional hydrostatic conditions, create righting arm curves, create a lines drawing or create an offset table.

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.

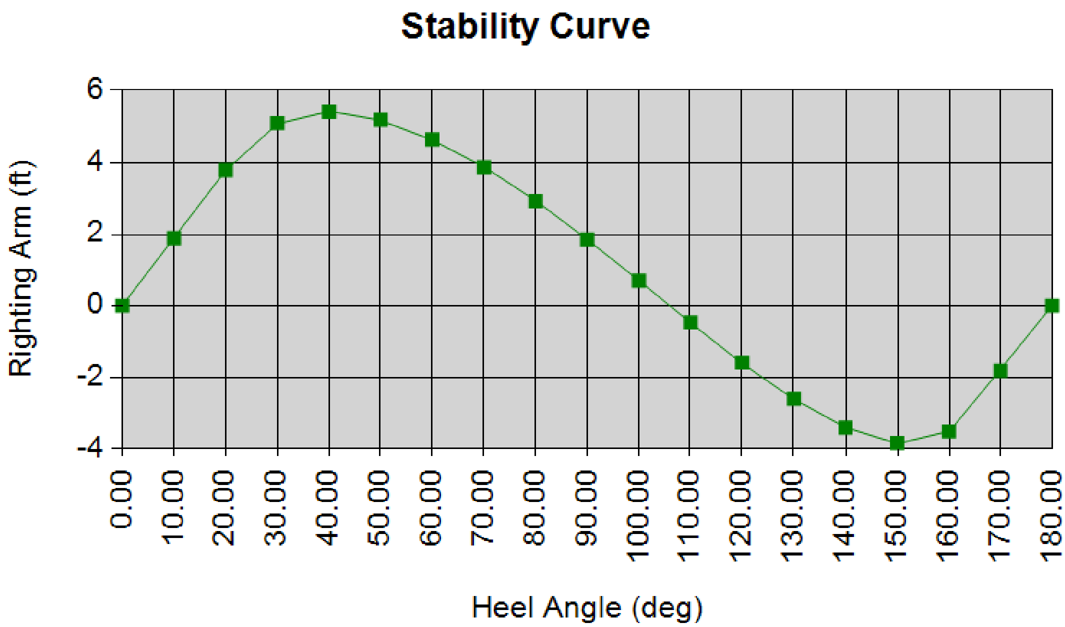
We will click the *Compute Righting Arm at these Heel Angles* box and input our desired heel angles in the corresponding text box. We are interested in angles 0 to 180 degrees in 10 degree increments so we can enter this as a comma separated list. When this box is selected, you must also enter a VCG.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

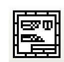


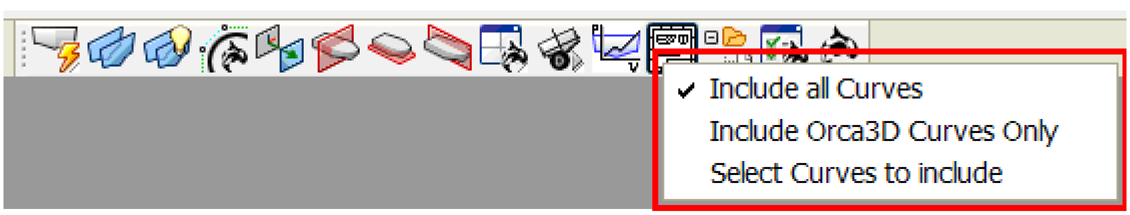
The hydrostatics and stability report provides your model dimensions, volumetric values, hull form coefficients and static stability parameters. The report also provides an immersed area and wetted girth plot (if stations are defined):



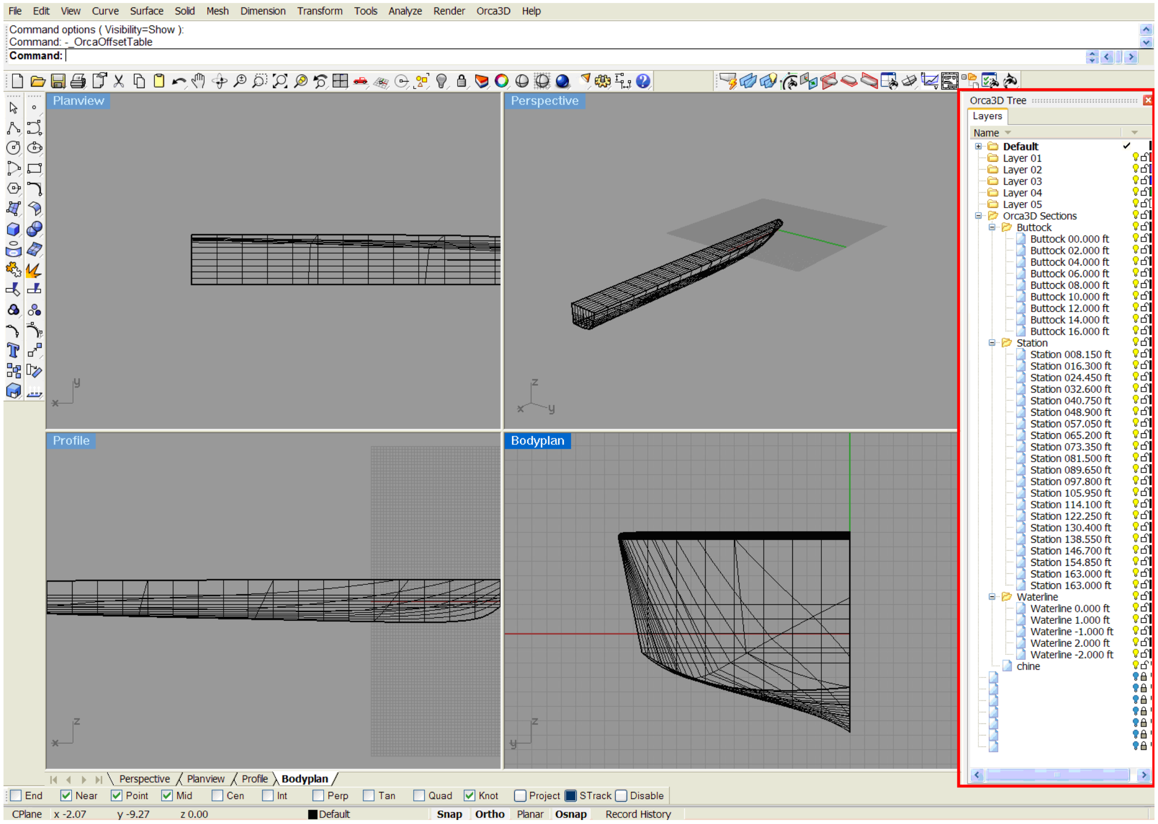
And a righting arm curve:



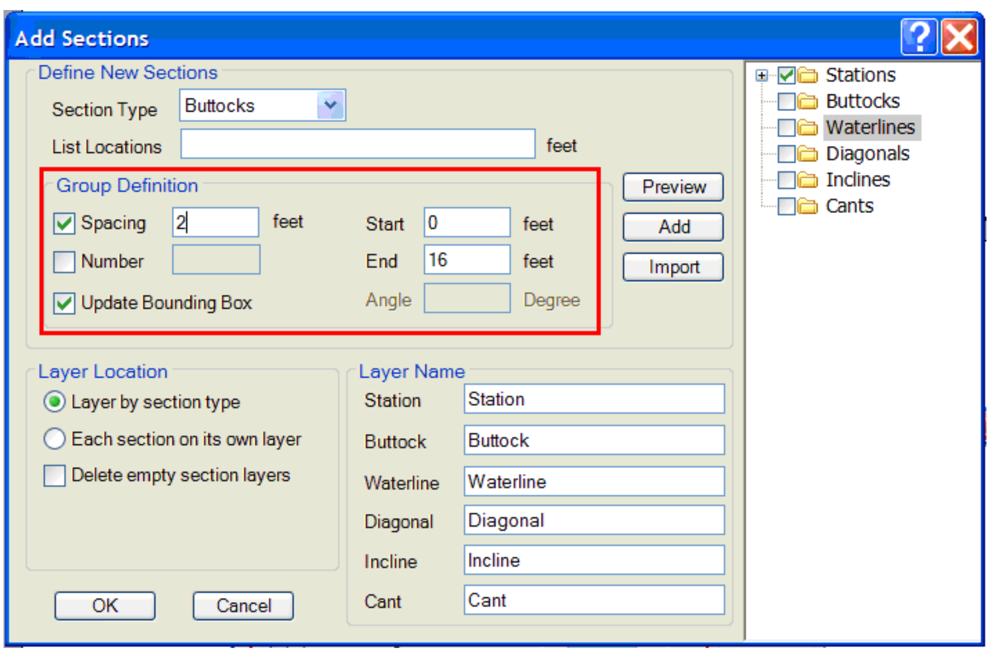
To create a table of offsets in Microsoft Excel, right-click on the Lines Drawing icon . This will bring up the option to *Include all Curves, Include Orca3D Curves Only,* or *Select Curves to include.*



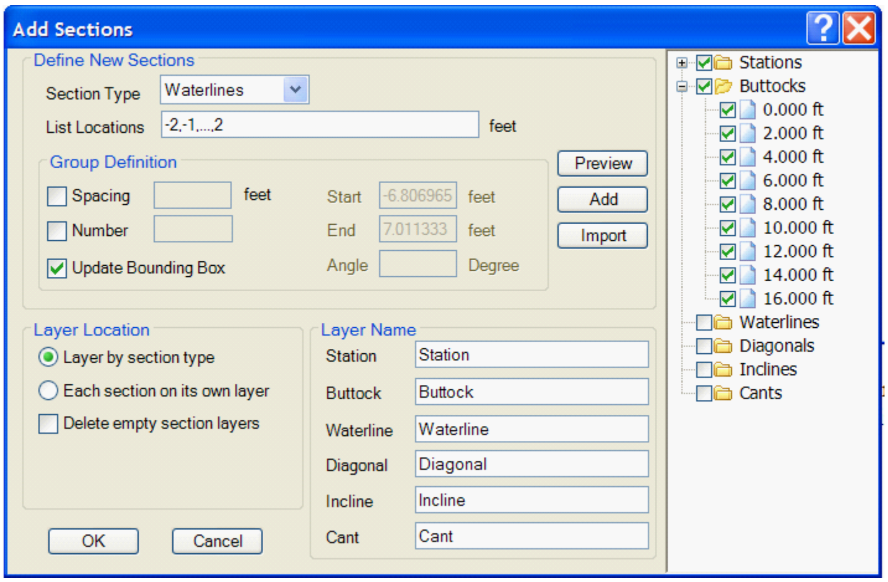
Including all curves will select all defined section curves, and any additional curves created in Rhino. For instance, you could create a curve along the chine and its offsets would then be included in the table. For this example we will create a chine curve. In order to do this, choose Curve from the 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.”



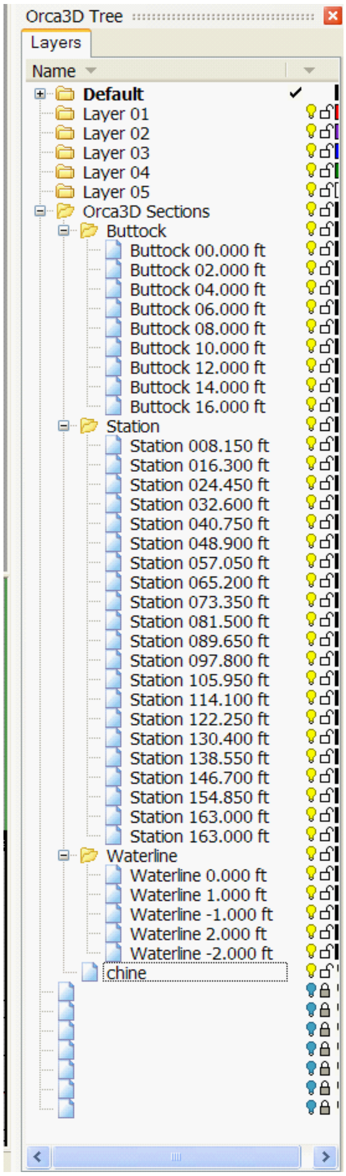
For a more detailed offset table, we will add buttocks and waterlines to our model using the same technique as we did to add sections. Highlight the hull surfaces and click the Orca3D Sections icon . We will now add buttocks spaced at 2 feet apart using the automatically updated bounds and click Add.



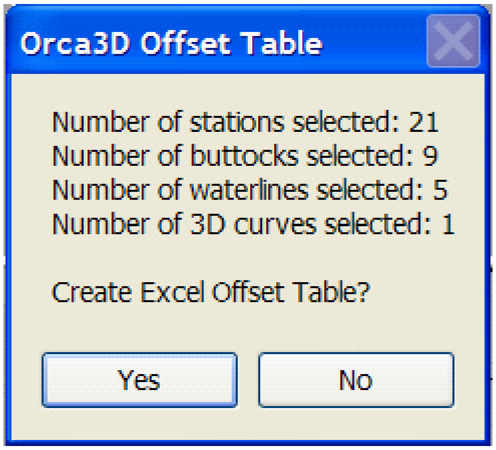
We will also add waterlines at -2,-1,0,1, and 2 feet. This can be entered as a comma separated list: -2,-1,…,2 in the List Locations text box and Orca will automatically add waterlines at the desired locations. Click Add.



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."

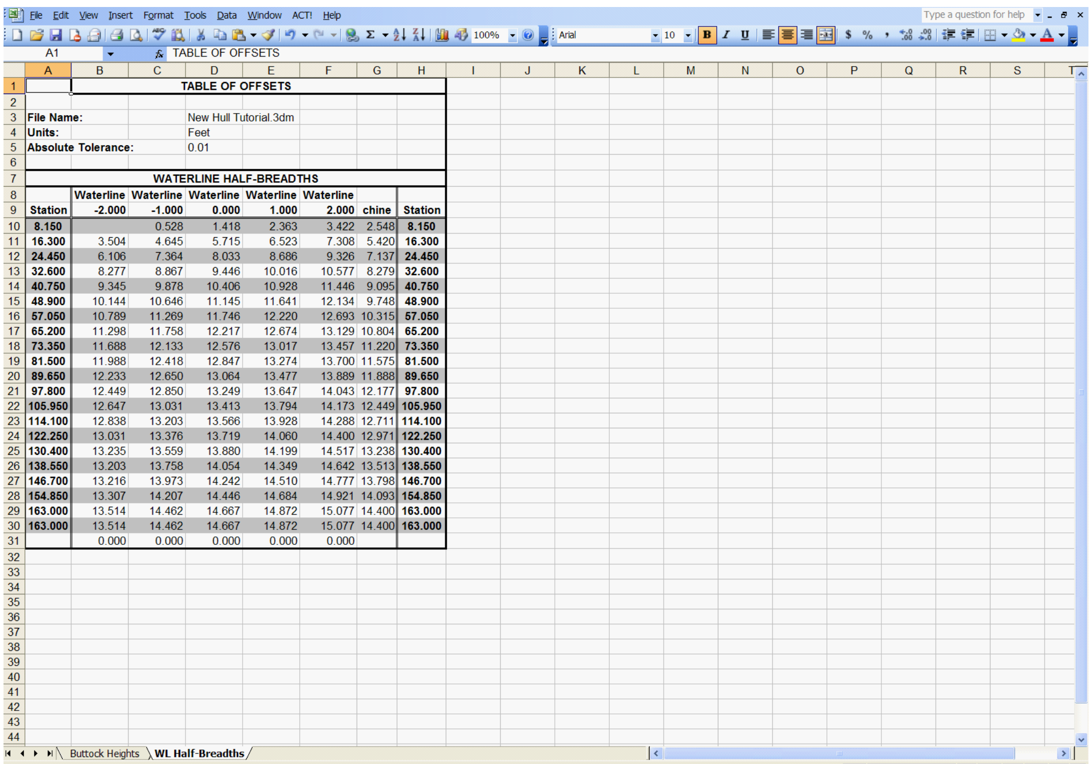


TABLE OF OFFSETS

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.

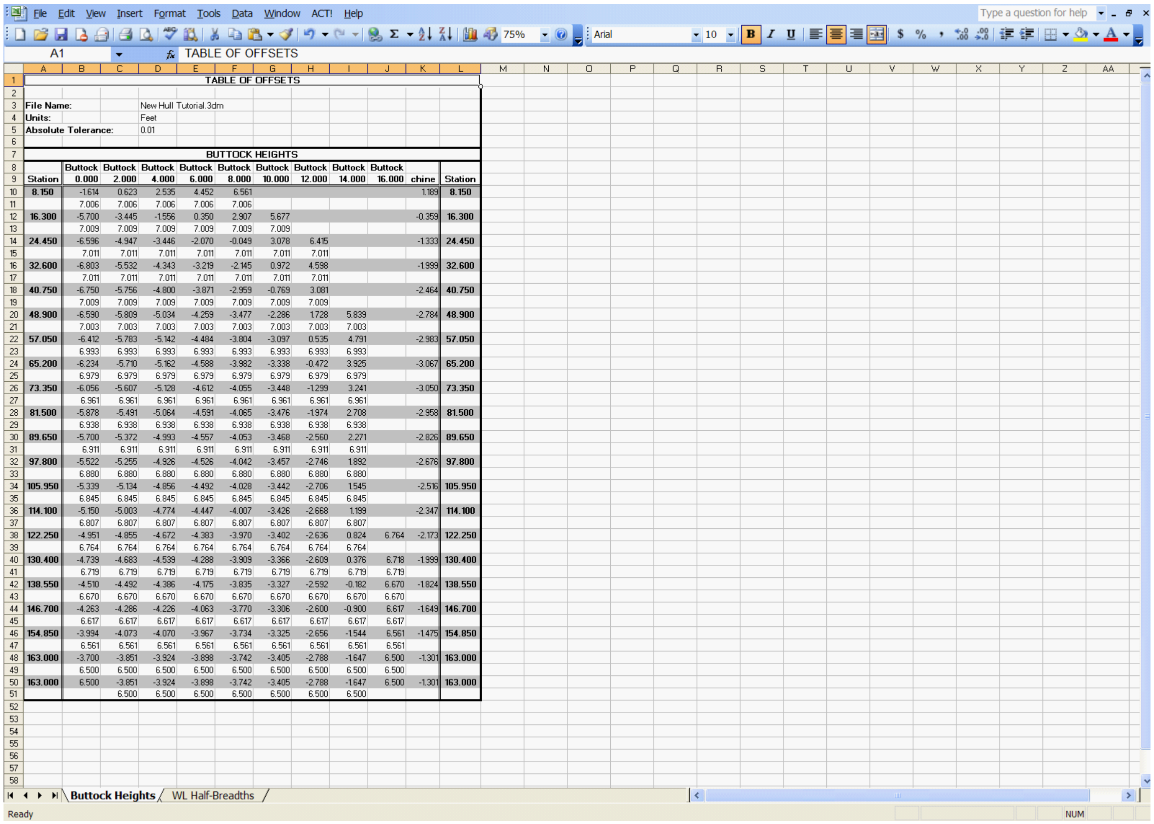


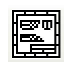
TABLE OF OFFSETS

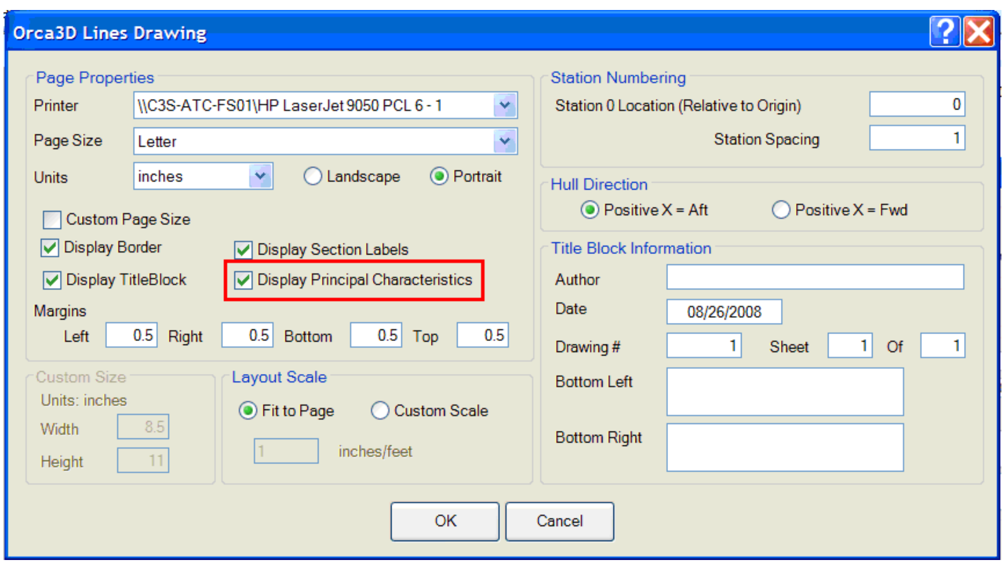
File Name: New Hull Tutorial.3dm
Units: Feet
Absolute Tolerance: 0.01

BUTTOCK HEIGHTS

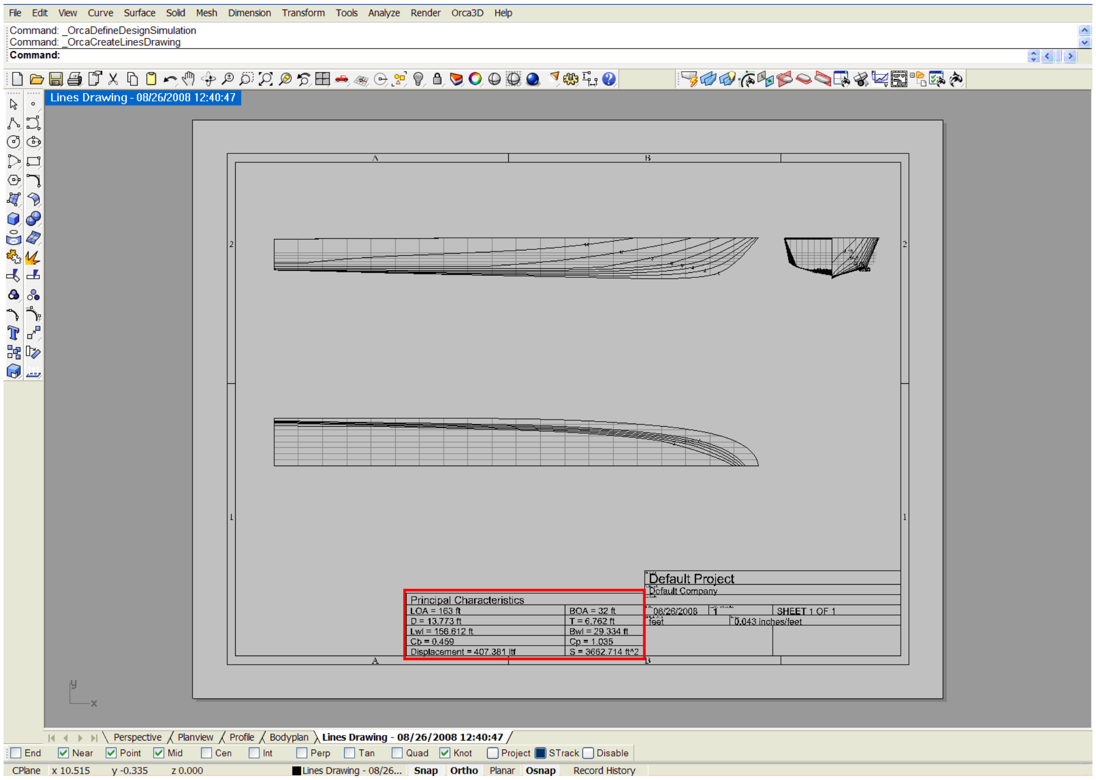
Station	Buttock 0.000	Buttock 2.000	Buttock 4.000	Buttock 6.000	Buttock 8.000	Buttock 10.000	Buttock 12.000	Buttock 14.000	Buttock 16.000	chine	Station
8.150	-1.614	0.623	2.535	4.452	6.561					1.189	8.150
	7.006	7.006	7.006	7.006	7.006						
16.300	-5.700	-3.445	-1.556	0.350	2.907	5.677				-0.359	16.300
	7.009	7.009	7.009	7.009	7.009	7.009					
24.450	-6.596	-4.947	-3.446	-2.070	-0.049	3.078	6.415			-1.333	24.450
	7.011	7.011	7.011	7.011	7.011	7.011	7.011				
32.600	-6.803	-5.532	-4.343	-3.219	-2.145	0.972	4.598			-1.999	32.600
	7.011	7.011	7.011	7.011	7.011	7.011	7.011				
40.750	-6.750	-5.756	-4.800	-3.871	-2.959	-0.769	3.081			-2.464	40.750
	7.009	7.009	7.009	7.009	7.009	7.009	7.009				
48.900	-6.590	-5.809	-5.034	-4.259	-3.477	-2.286	1.728	5.839		-2.784	48.900
	7.003	7.003	7.003	7.003	7.003	7.003	7.003	7.003			
57.050	-6.412	-5.783	-5.142	-4.484	-3.804	-3.097	0.535	4.791		-2.983	57.050
	6.993	6.993	6.993	6.993	6.993	6.993	6.993	6.993			
65.200	-6.234	-5.710	-5.162	-4.588	-3.982	-3.338	-0.472	3.925		-3.067	65.200
	6.979	6.979	6.979	6.979	6.979	6.979	6.979	6.979			
73.350	-6.056	-5.607	-5.128	-4.612	-4.055	-3.448	-1.299	3.241		-3.050	73.350
	6.961	6.961	6.961	6.961	6.961	6.961	6.961	6.961			
81.500	-5.878	-5.491	-5.064	-4.591	-4.065	-3.476	-1.974	2.708		-2.958	81.500
	6.938	6.938	6.938	6.938	6.938	6.938	6.938	6.938			
89.650	-5.700	-5.372	-4.993	-4.557	-4.053	-3.468	-2.560	2.271		-2.826	89.650
	6.911	6.911	6.911	6.911	6.911	6.911	6.911	6.911			
97.800	-5.522	-5.255	-4.926	-4.526	-4.042	-3.457	-2.746	1.892		-2.676	97.800
	6.880	6.880	6.880	6.880	6.880	6.880	6.880	6.880			
105.950	-5.339	-5.134	-4.856	-4.492	-4.028	-3.442	-2.706	1.545		-2.516	105.950
	6.845	6.845	6.845	6.845	6.845	6.845	6.845	6.845			
114.100	-5.150	-5.003	-4.774	-4.447	-4.007	-3.426	-2.668	1.199		-2.347	114.100
	6.807	6.807	6.807	6.807	6.807	6.807	6.807	6.807			
122.250	-4.951	-4.855	-4.672	-4.383	-3.970	-3.402	-2.636	0.824	6.764	-2.173	122.250
	6.764	6.764	6.764	6.764	6.764	6.764	6.764	6.764			
130.400	-4.739	-4.683	-4.539	-4.288	-3.909	-3.366	-2.609	0.376	6.718	-1.999	130.400
	6.719	6.719	6.719	6.719	6.719	6.719	6.719	6.719	6.719		
138.550	-4.510	-4.492	-4.386	-4.175	-3.835	-3.327	-2.592	-0.182	6.670	-1.824	138.550
	6.670	6.670	6.670	6.670	6.670	6.670	6.670	6.670	6.670		
146.700	-4.263	-4.286	-4.226	-4.063	-3.770	-3.306	-2.600	-0.900	6.617	-1.649	146.700
	6.617	6.617	6.617	6.617	6.617	6.617	6.617	6.617	6.617		
154.850	-3.994	-4.073	-4.070	-3.967	-3.734	-3.325	-2.656	-1.544	6.561	-1.475	154.850
	6.561	6.561	6.561	6.561	6.561	6.561	6.561	6.561	6.561		
163.000	-3.700	-3.851	-3.924	-3.898	-3.742	-3.405	-2.788	-1.647	6.500	-1.301	163.000
	6.500	6.500	6.500	6.500	6.500	6.500	6.500	6.500	6.500		
163.000	6.500	-3.851	-3.924	-3.898	-3.742	-3.405	-2.788	-1.647	6.500	-1.301	163.000
		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.



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 VI

6 The Orca3D Tree

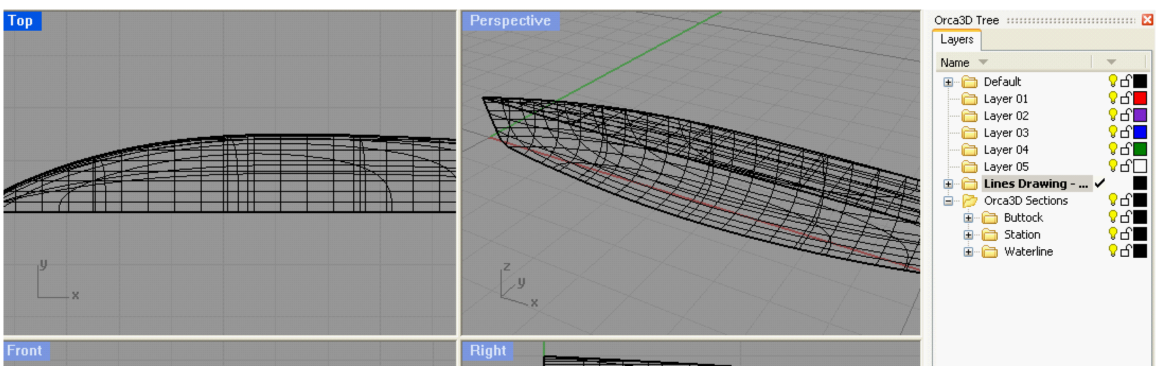
The Orca3D Tree is a utility that improves upon the default layers utility in Rhino. In addition to the typical layer capabilities of visibility, locking and changing the color, it allows you to:

- 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:

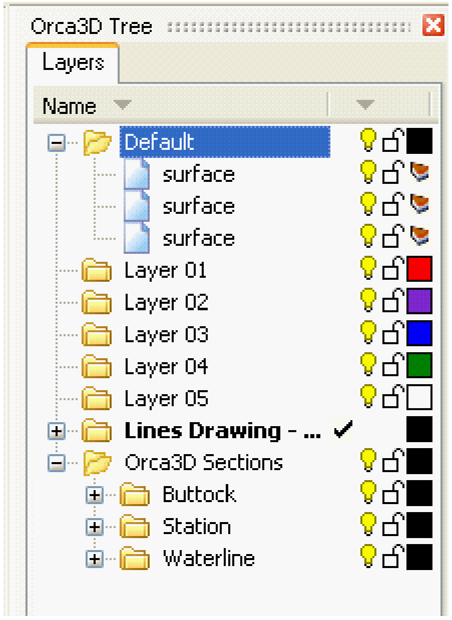


3. Decide which function of the Orca3D Tree you wish to perform and find the instructions below.

<u>**Show all Objects in a Layer**</u>

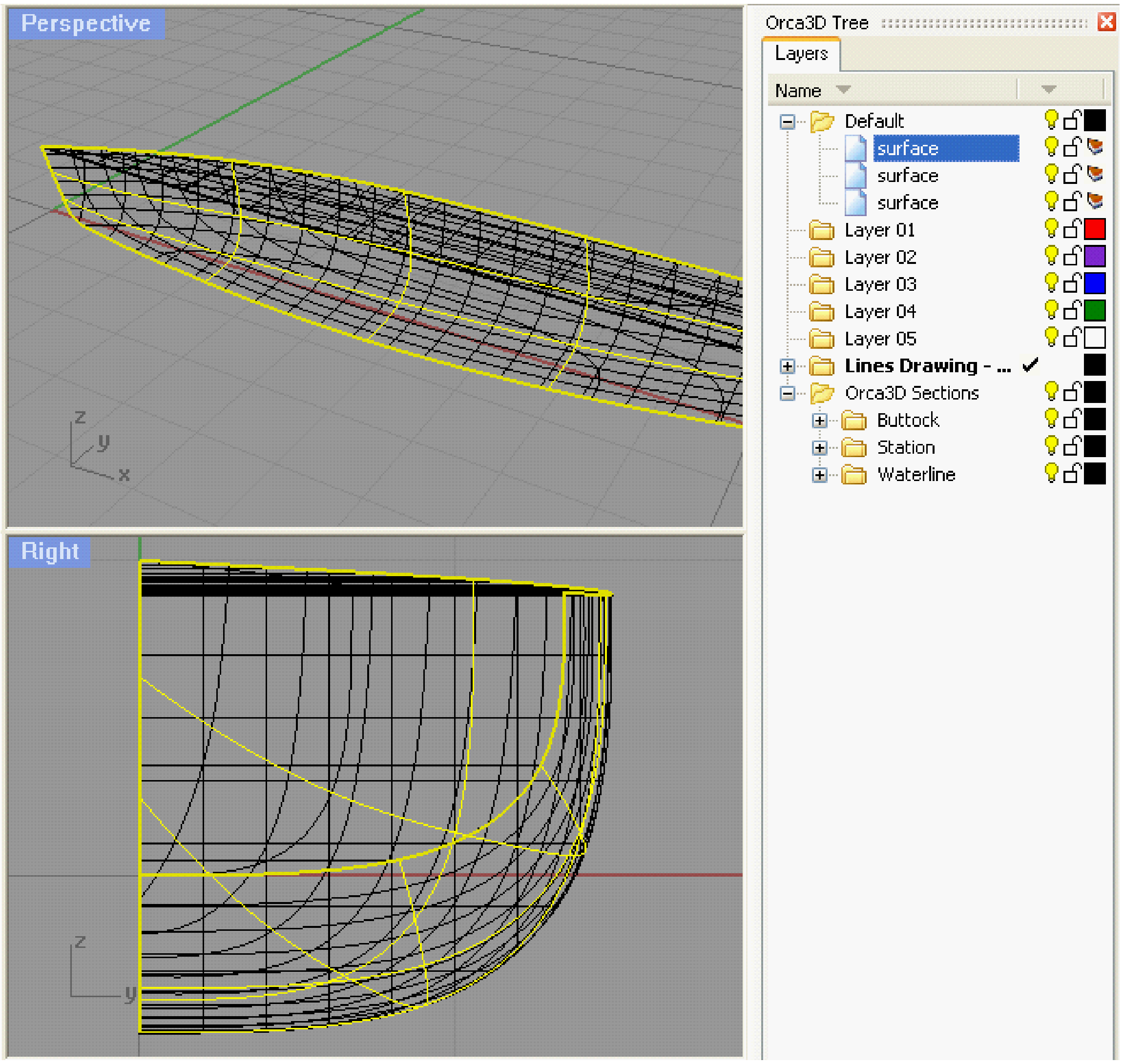
4. Decide which layer you wish to see more details of and click the plus icon to the left of the layer name.

5. 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.

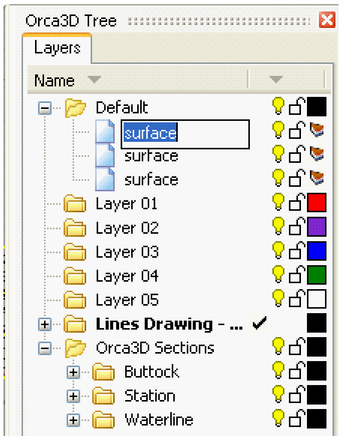
6.

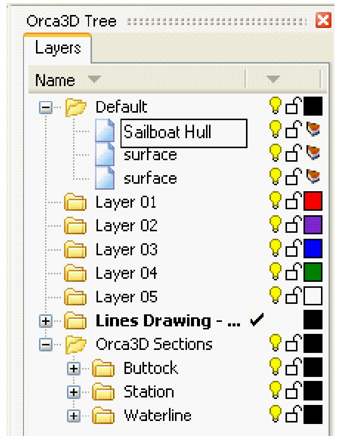


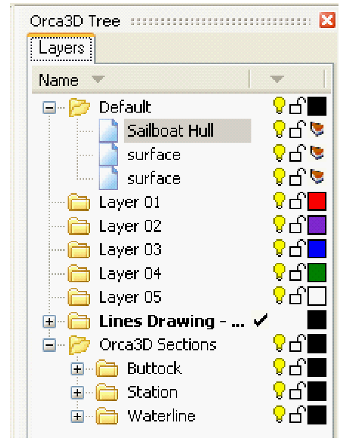
7. If you select one of the objects in the Orca3D Tree, the same object will be selected in the viewports you have opened. Conversely, selecting objects in the viewports will also select them in the tree.

Renaming Objects using the Orca3D Tree

8. 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.

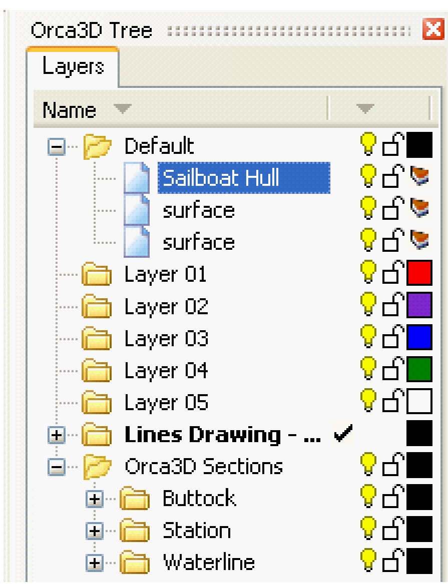


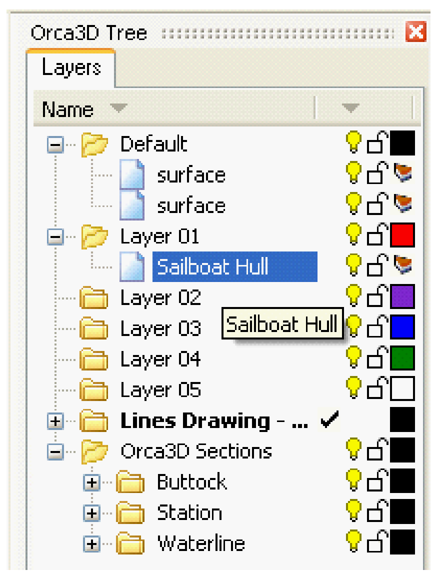




Moving Objects from Layer to Layer

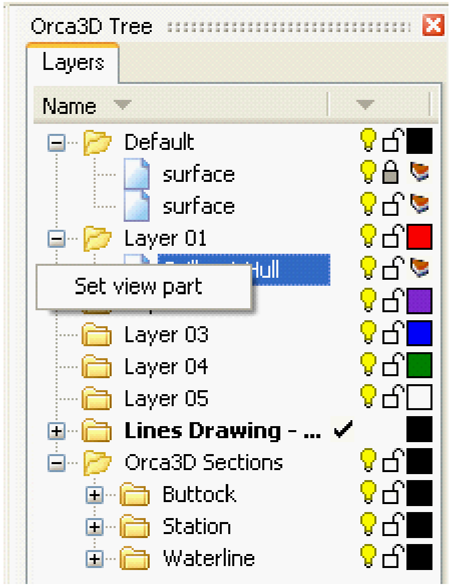
9. First, decide which object you would like to move.
10. Next, select that object and left-click and hold. Then move the mouse to hover over the layer which you wish to move the object to, and release the left mouse button.





Hiding Objects

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

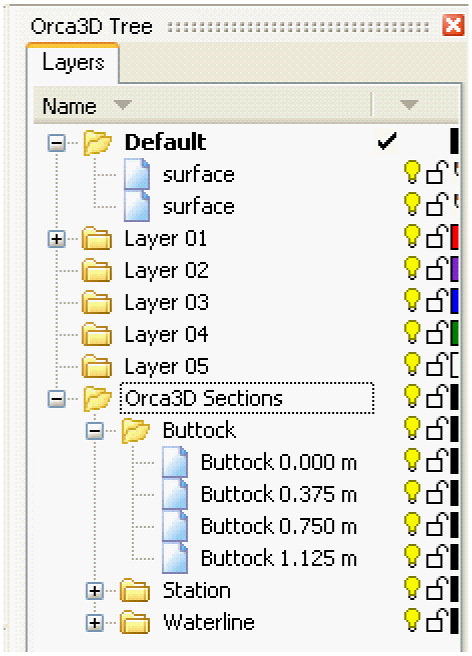


12. Left-click the option “set view part” and everything but the objects you have selected will become invisible.
13. To return everything to normal, simply click the lightbulb icons next to the objects you wish to make visible again.
14. To hide the docked Orca3D Tree dialog box simply either click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

Understanding Orca3D Tree

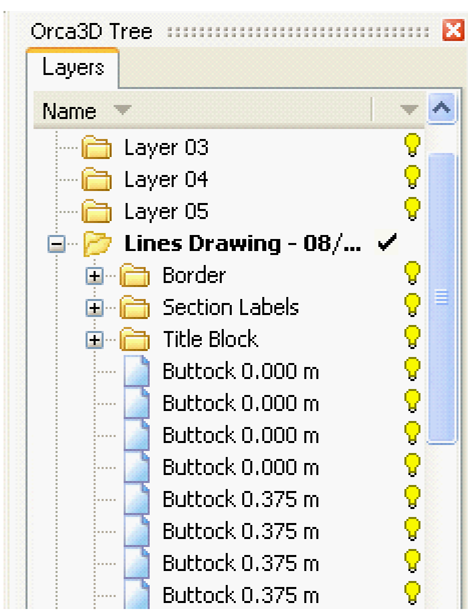
The objects that Orca3D creates and are visible in the Orca3D Tree include the hull surfaces, section curves, and lines drawing curves and objects. As you can see from above, the hull surfaces are placed into whatever the current layer is at their time of creation. On the other hand, the Orca3D sections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

7 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 17
Quick Start Tutorial 31
FAQ-Hull Design & Fairing 140

7.1 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 73)
- Define stations, buttocks, waterlines, and other curves on the surface (Sections 38)
- Display the sections in real time as the surface is modified (Orca Control Points 34)

- Display the hydrostatics in real time as the surface is modified (Design Hydrostatics 42)
- Easily move control points to exact locations (OrcaMove 34)
- Handle the transition of the surface as it wraps from the stem around the forefoot to the bottom, with slope and curvature continuity (Corner Continuity 73)
- Create 3-View Lines Drawings 76
- Create Tables of Offsets 83
- Export 86 section curves

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

7.2 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.

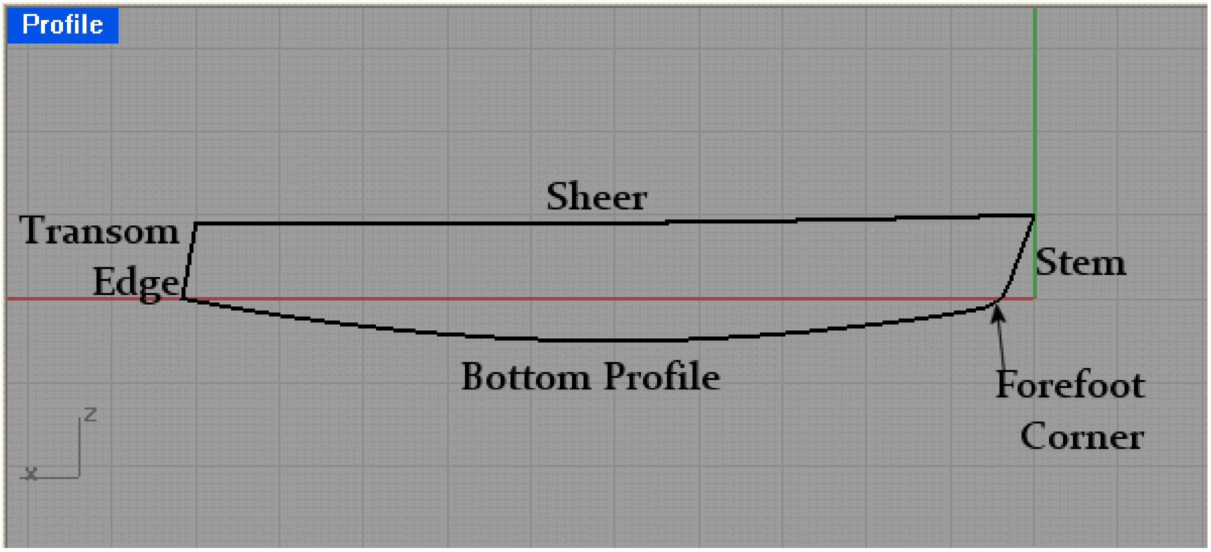
For complete information on the Hull Assistants, please see the Hull Assistants 31 topic in the Quick Start Tutorial section.

7.3 Corner Continuity

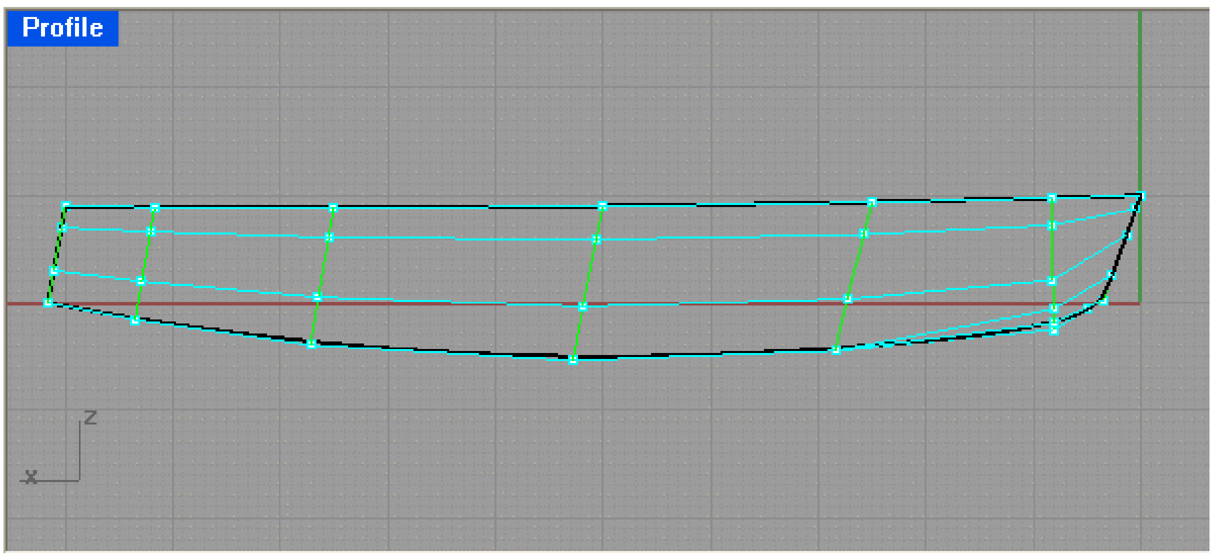
Toolbar	***n/a***
Menu	**Orca3D > Hull Design > Corner Continuity**
Command	**OrcaWrapCorner**

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 edge. 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).

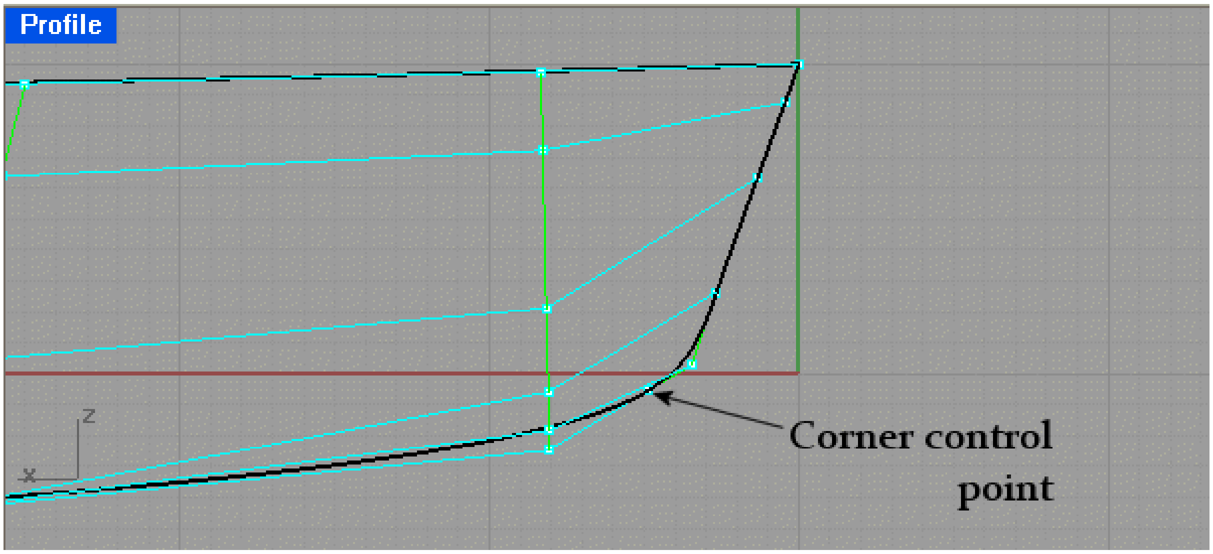
Note: The Corner Continuity command requires that the surface have the same degree in both directions.



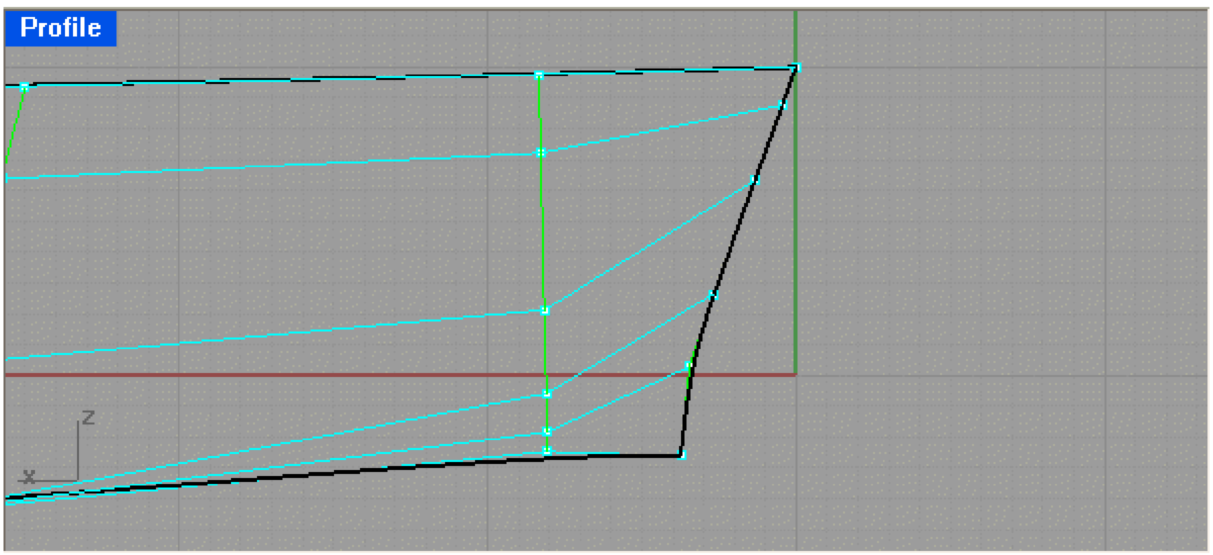
Orca3D provides a function to precisely place the corner control point to create this smooth transition. The next figure shows the Orca control polygon:



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



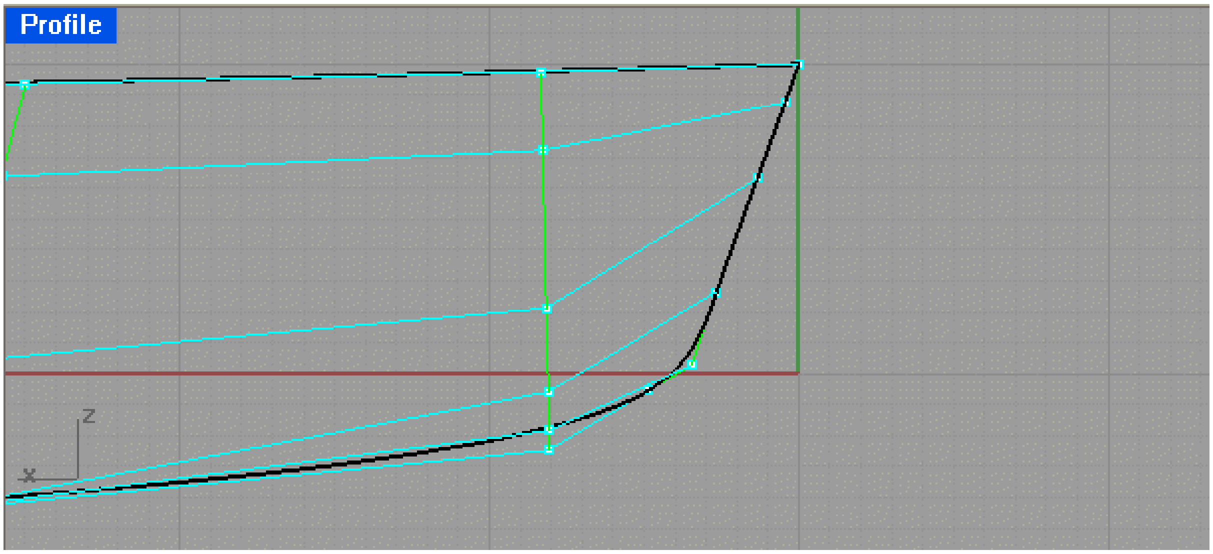
To demonstrate the function, the corner control point has been moved, deliberately creating a discontinuity in the joint between the stem and the bottom profile:



To re-create the smooth transition, select the **Corner Continuity** 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 ( CornerU0V0=No  CornerU0V1=No  CornerU1V0=No  CornerU1V1=No ):
```

By clicking on any corner of the surface, its corresponding Corner will toggle between "No" and "Yes." 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.

7.4 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. (For more information on Layout views in Rhino, see Rhino's documentation on the **Layout** command.)

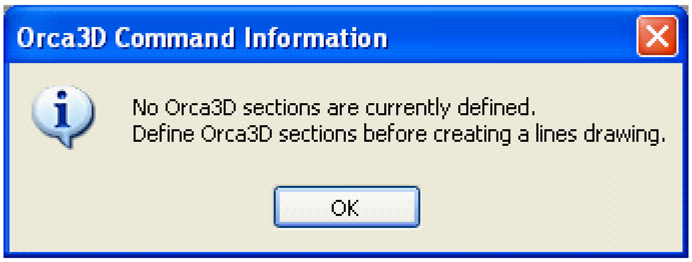
Orca3D's Lines Drawing command contains options to add section labels, a border, a title block, and principal characteristics. These objects are all added into separate layers so you can turn their visibility on and off with ease.

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 42 in the Stability section of Orca3D.

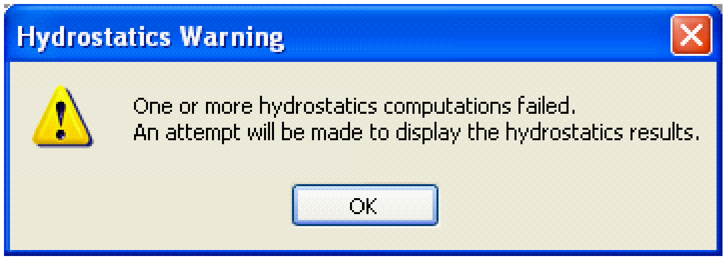
- When printing, if you wish your lines drawing to be printed correctly on the indicated paper size make sure to select the printing scale as 1:1, and set the output color to display colors.
- If you wish station annotations to contain station locations instead of station numbers, simply enter the most forward point of your hull for the Station 0 location, and type 1 as the station separation.

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 96 before using the OrcaCreateLinesDrawing command.

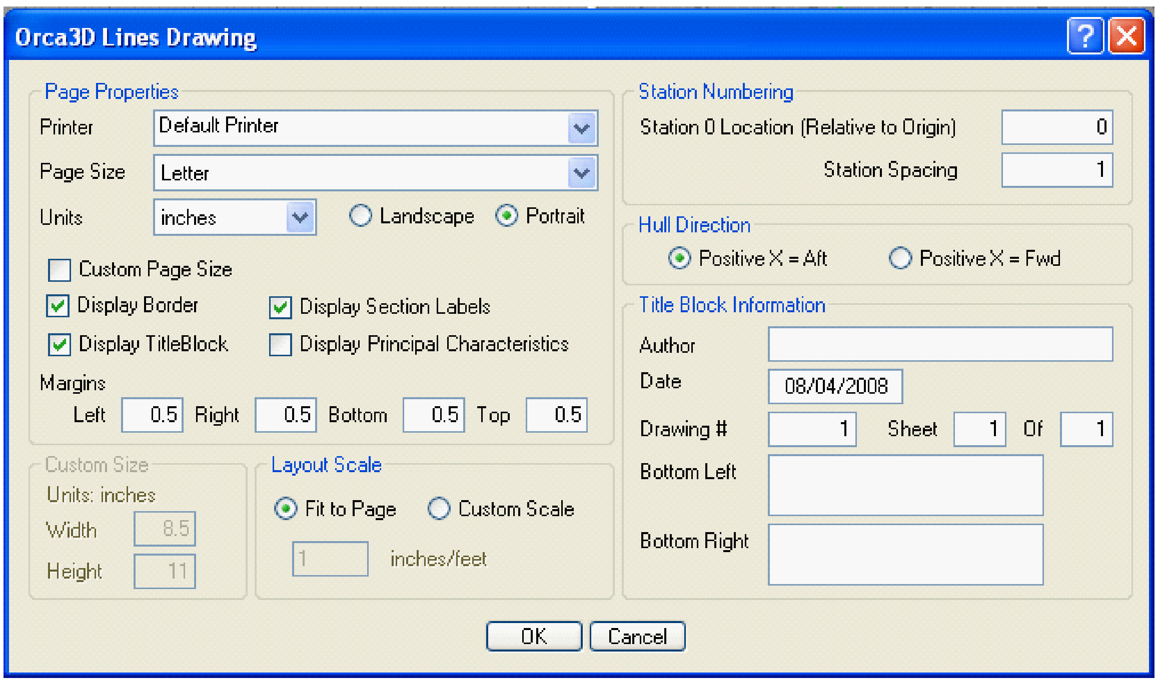


   b. If this dialog box appears, then you have not defined a Design Condition. You may still continue to create the lines drawing, but if you wish to include principal characteristics in your drawing, you must first define the Design Condition 42.

   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 42 correctly.



2. The Orca3D Lines Drawing dialog box will appear:



Page Properties

3. Select the printer that has the paper size you wish to use.
4. Select the Page size that you wish your lines drawing to be created on.
5. Select the units for the page size.
6. Select whether you wish the page to be in landscape or portrait format.
7. 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.
8. Check any of the next four check boxes depending on what you wish to be visible on the lines drawing.
9. Edit the paper margins. They are in the units you selected above.

Layout Scale

10. 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.

Station Numbering

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

Hull Direction

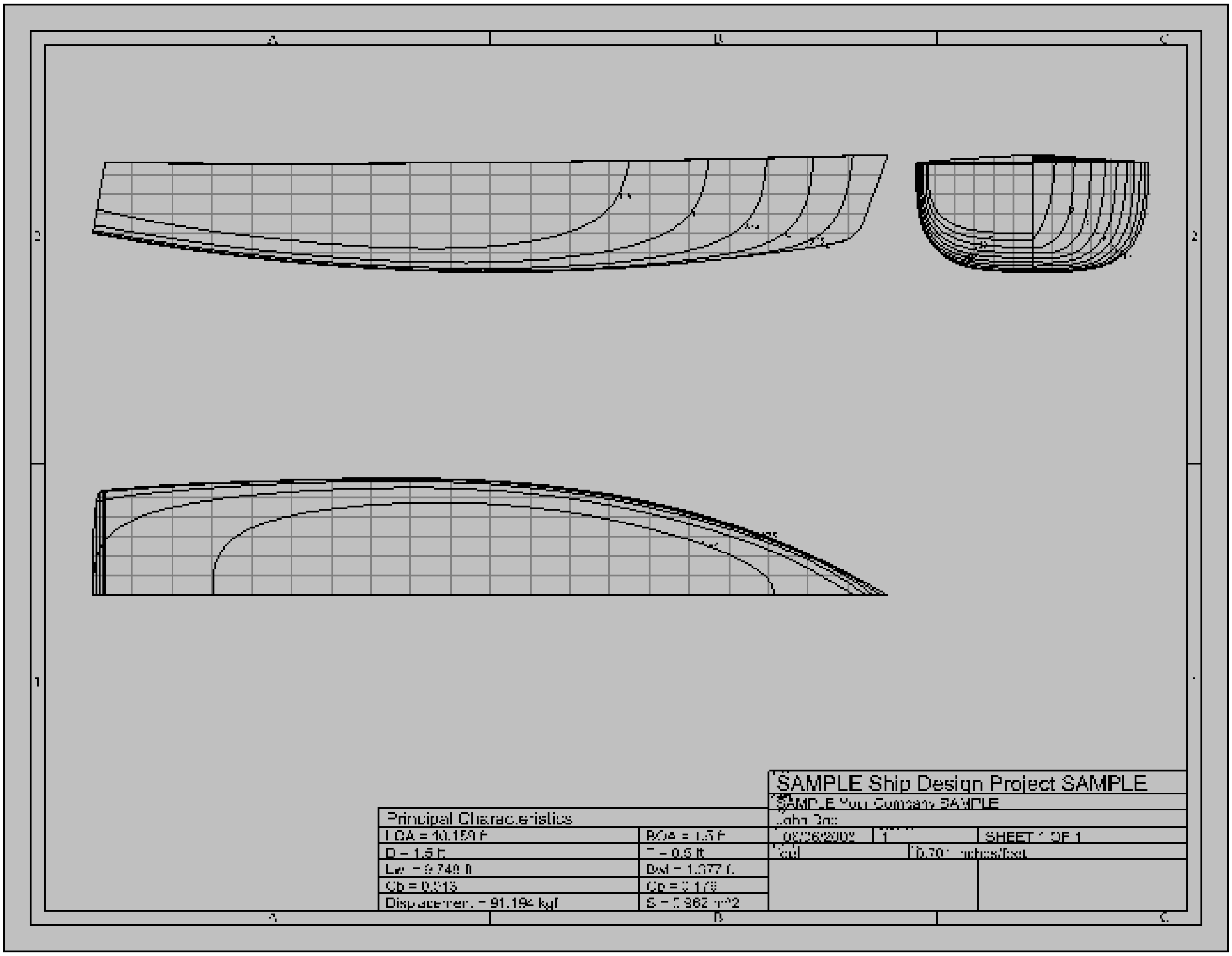
13. Select whether the positive X direction is Aft or Forward.

Title Block Information

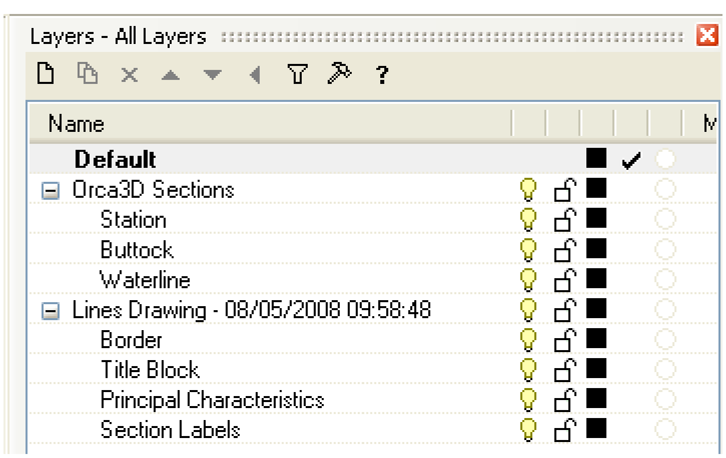
14. If you selected "Display Title Block" in the Page Properties section, you can edit the specifics of the title block here.
    a. Fill in all of the named items with the appropriate information.
    b. The bottom left and bottom right items are to be used at your discretion. They can be filled with whatever information you want within your title block.

15. Select OK

16. Your lines drawing is created using the information you provided.



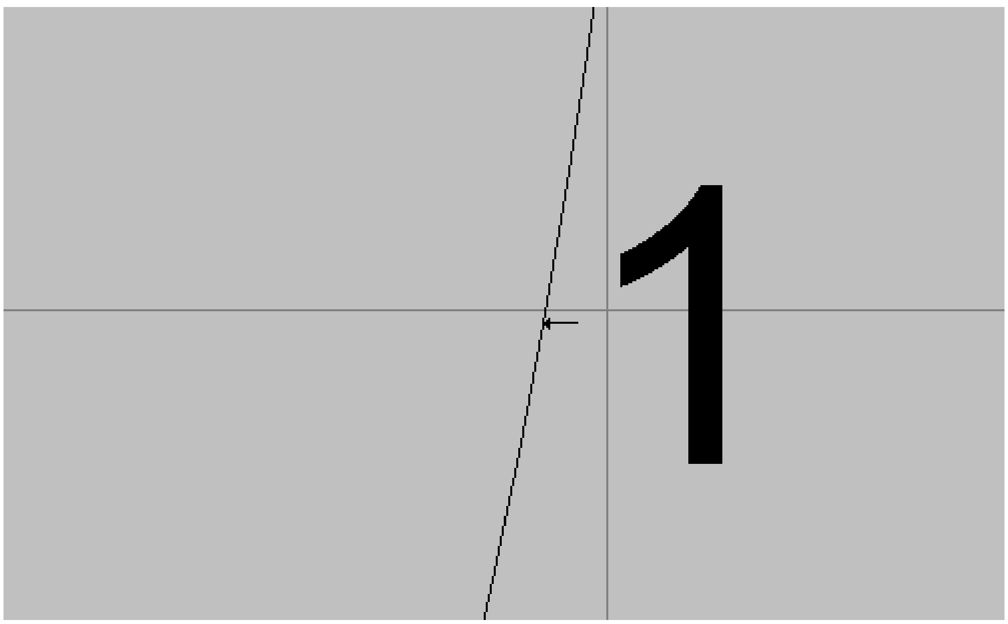
You will notice the objects in separate layers, as shown below:

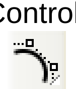


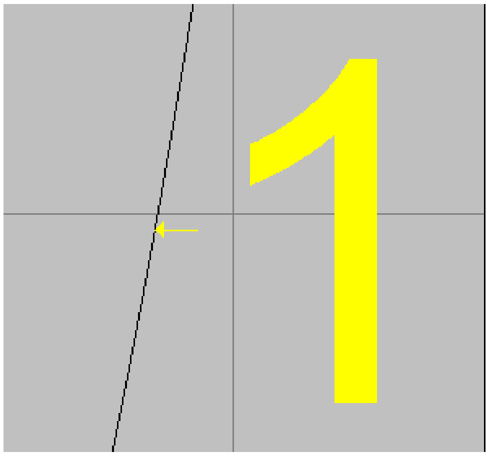
You may turn off visibility, lock, or delete the layers as you wish to better manage your lines drawing.

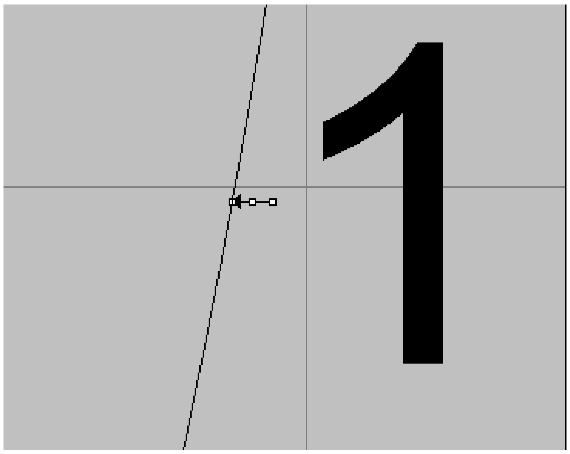
The Layout and the Layer will be labeled with the time and date that the Lines Drawing was created. The drawing will be up to date with the model as of that time. Any further changes to the model *are not* reflected automatically in the Lines Drawing. You will need to create a new Lines Drawing if you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

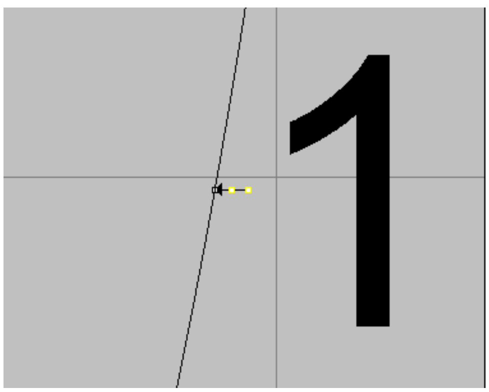


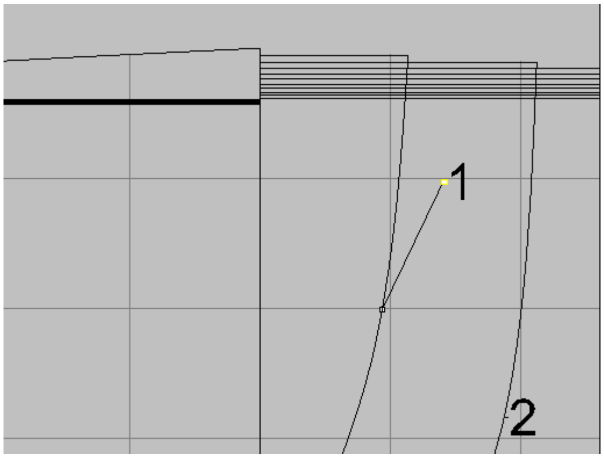
Then turn the Rhino control points on by selecting the section label and either navigating the menu to (Edit > Control Points > Control Points On) , typing PointsOn in the command line, or left-clicking the  icon.





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.

7.5 Offset Tables

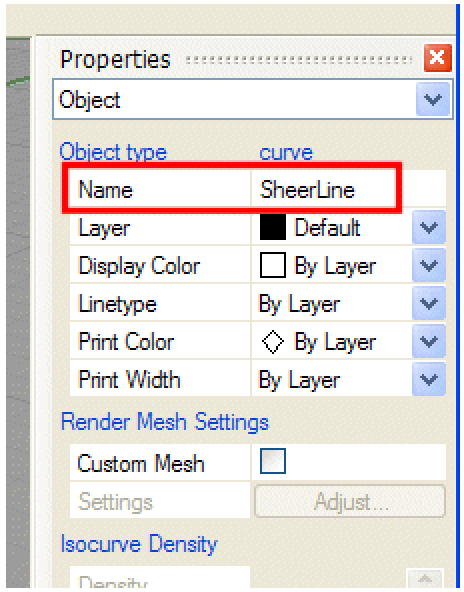
Although most vessels are built with numeric methods, sometimes a traditional table of offset is still required. Orca3D can produce a table in Excel showing buttock heights, waterline half-breadths, and 3D curve (sheer, chine, etc.) intersections with tables.

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

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

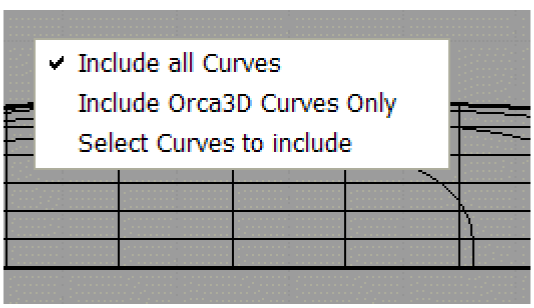
The first step to creating a table of offsets is to create the curves that will be included. These can be created with the Orca Sections command, or any other curve creation routines in Rhino. In particular, you may wish to define curves for:

- 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.

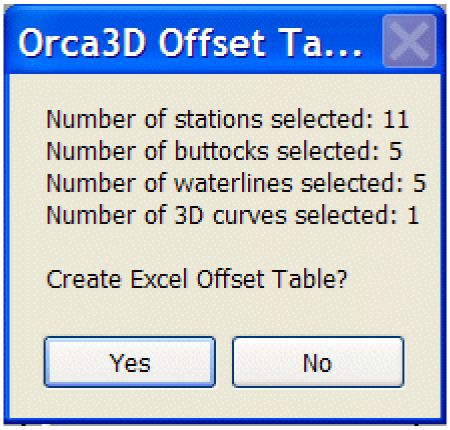
Start the OrcaOffsetTable command from the command line, the menu, or by right-clicking on the icon. You will immediately see the prompt asking what type of curves to include in the offset table:



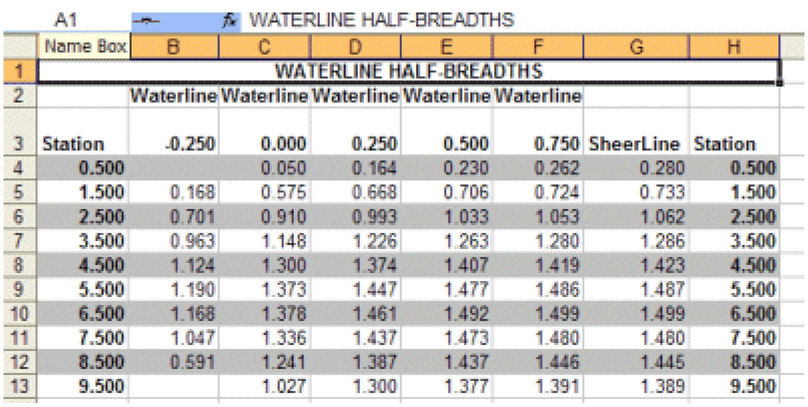
- **Include all Curves:** All of the curves in your model will be included. They are tested to see if they are planar, and lie in a station, buttock, or waterline plane. If they do not, they are treated as "3D curves." If you have named the curves, their names will be shown in the output. If not, they will simply be labeled "3D Curve."
- **Include Orca3D Curves Only:** This will select all stations, buttocks, waterlines, diagonals, cants, and inclines that were defined in the Orca Sections 95 dialog.
- **Select Curves to include**: You will be prompted to select the curves that you would like to have included. Hit Enter when you are finished selecting.

No matter which method you use, the program must be able to find at least one station, and at least one buttock, waterline, or 3D curve. *Note: The number of buttocks plus 3D curves and number of waterlines plus 3D curves must not exceed 24.*

A dialog will appear with the number of curves of each type that have been found:



Click on Yes to create the table. An instance of Excel will be opened, and the data filled in the worksheets:



A1 | WATERLINE HALF-BREADTHS

	A	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	

7.6 Exporting Curves

Toolbar	***n/a***
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 88 for the IDF specification for Sections.

PIAS: This interface exports stations only 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 Curves

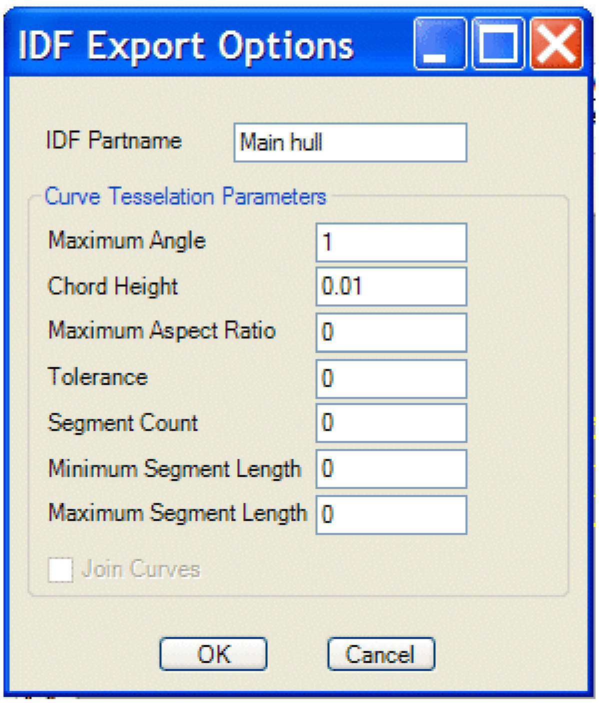
-Longitudinal Location of the curve

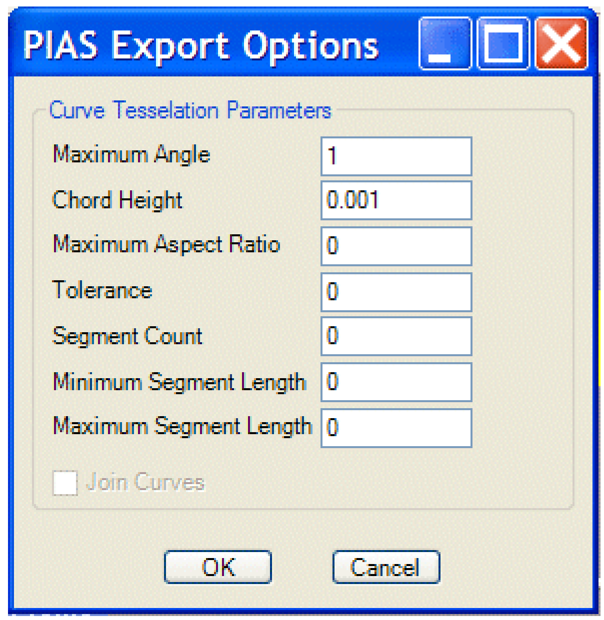
-Number of points in the curve

-Half Breadth, Height, Breakpoint Indicator

-Next curve...

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:





The values on these two 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 <= 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 VIII

8 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 17
Quick Start Tutorial 31

8.1 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 99, 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.

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).

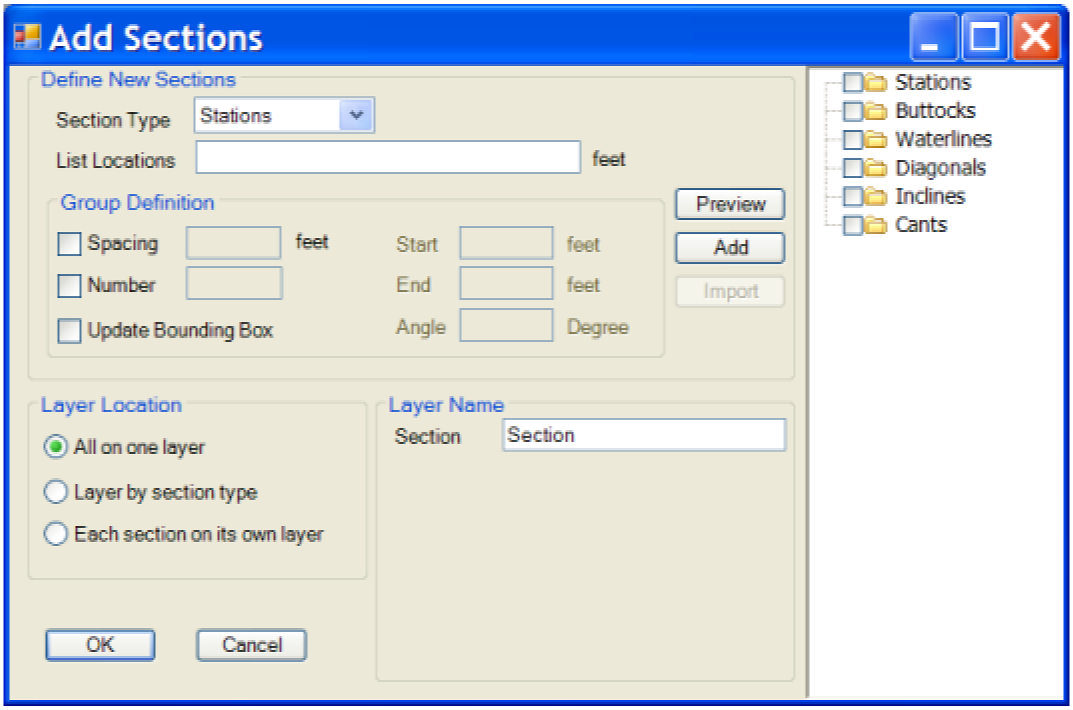
4. If you mirror Orca3D sections, either by themselves or along with their parent surface, the mirrored sections will be Rhino curve object, and not Orca3D sections. They can be moved, edited, and deleted like any other Rhino curves, *and will not update as the surface is modified*.

8.2 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.

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.

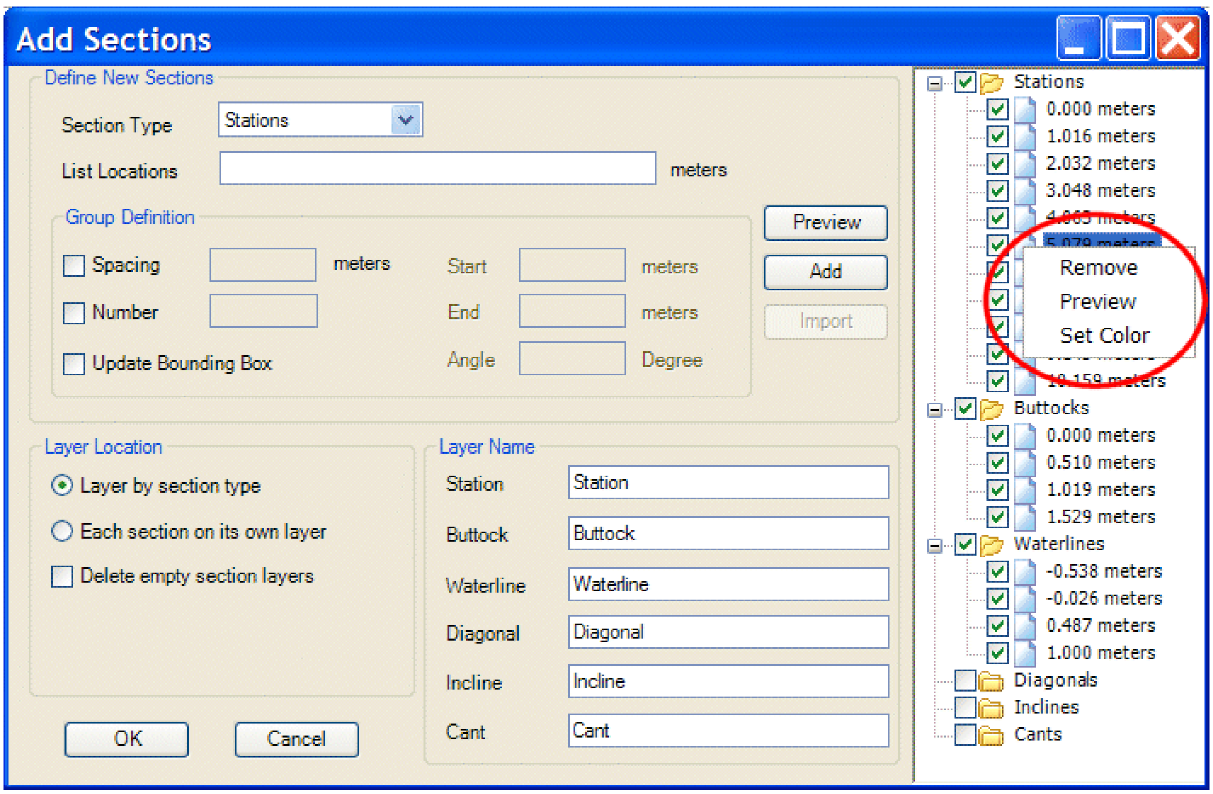
14. The calculation and visibility of all of the Sections may be temporarily turned off, using the **OrcaShowSection** command, or the icon (). Individual Sections or groups of Sections may be turned off with the checkbox in the Sections tree. When turned off, the Sections will not be computed or displayed, 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.

8.3 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 setctions 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).



8.4 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.

8.5 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.*

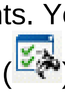
The first step is to define sections 96. After that, simply use the Orca Control Points when editing the surface(s).

Orca Control Points

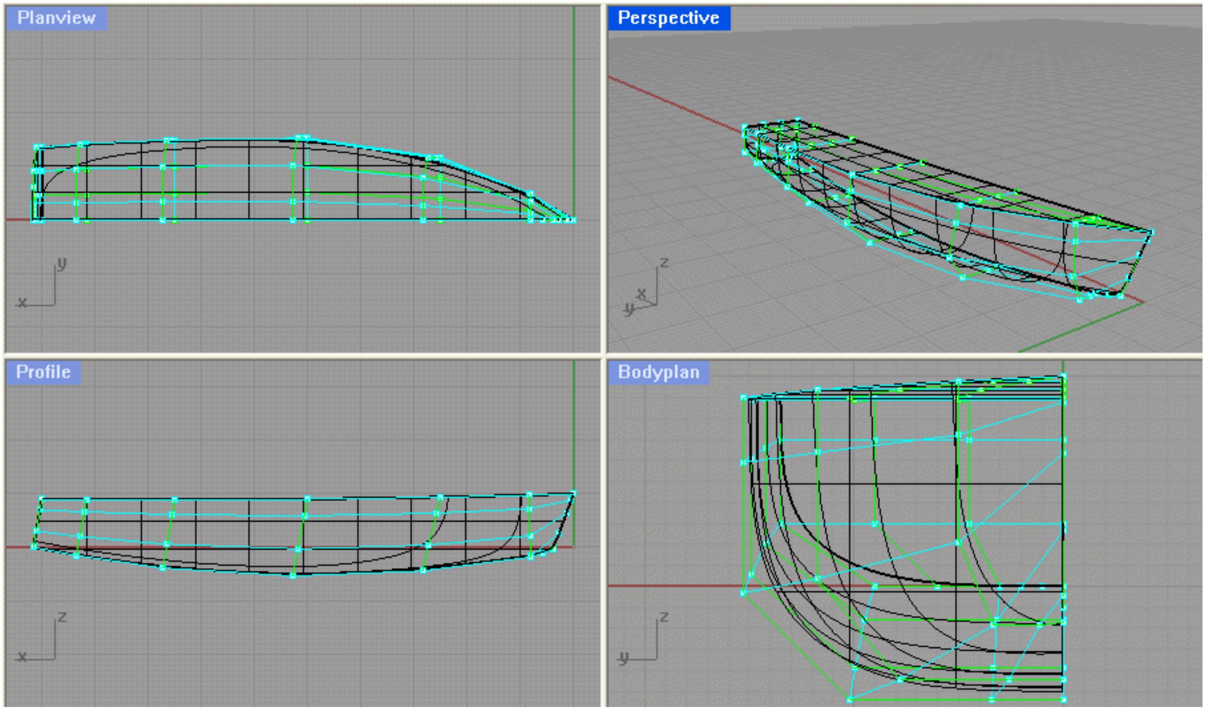
Toolbar	
Menu	**Orca3D > Hull Design > Orca3D Control Points On**
Command	**OrcaPointsOn**

1. Start the command from the toolbar, menu, or command line.

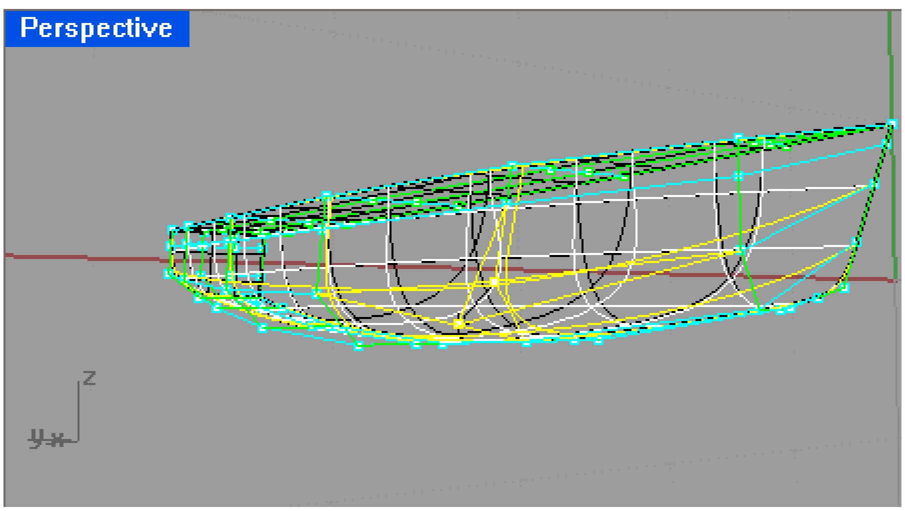
2. Select the surface(s) you wish to edit, and hit Enter.

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). If you have checked the Real-Time Hydrostatics box in the Define Design Condition 42 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

Part IX

9 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 17
Quick Start Tutorial 31
FAQ-Hydrostatics & Stability 141

9.1 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 44 (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 flotation plane or the weight/CG), and then the analysis can be run with a single button click, without having to define the flotation condition each time.

Note: It is assumed that the model's centerplane is at 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 186 section of the Verification and Testing 166 chapter, to see how various mesh settings affect the accuracy of the results.

9.2 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:

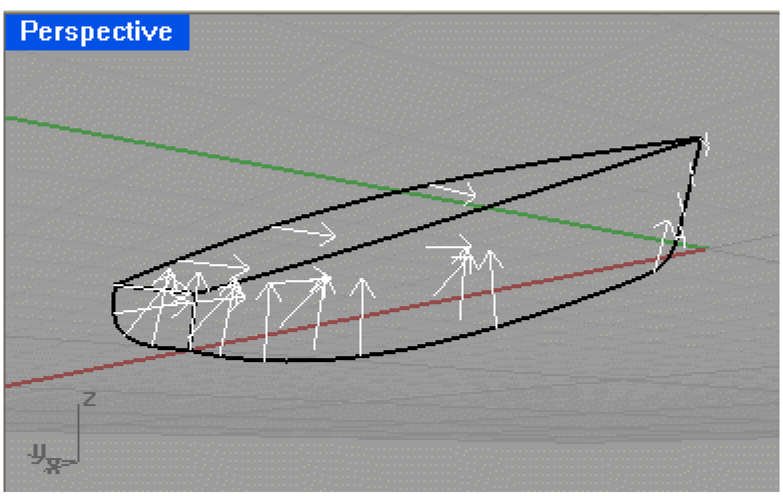
- May be composed of surfaces, polysurface, meshes, or any combination of these;
- While the model does not need to be completely sealed ("watertight"), any gaps in the model will decrease accuracy;
- Any naked edges should not become submerged; for example, if the model does not have a deck, it will 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.*

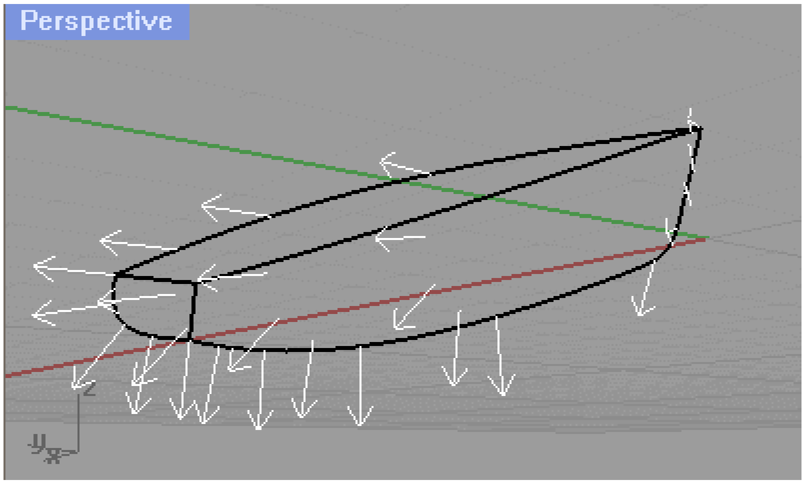
Orca3D computes most of the hydrostatic data from a surface mesh, not with the traditional approach of integrating stations. The user has control over the density of this mesh, just as you do with Rhino's display or analysis mesh. If the mesh is too coarse, your values will be low. If they are too high, it will slow down the computations without adding appreciable accuracy. The settings may be adjusted using the OrcaProperties 24 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.

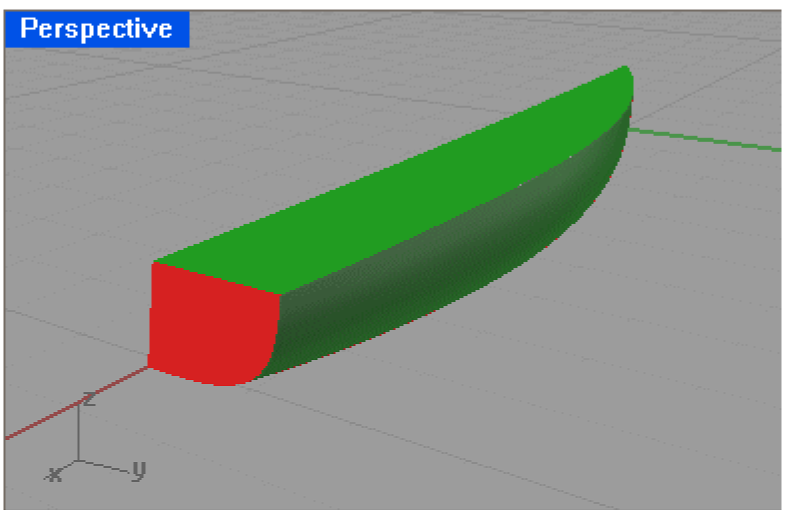


Incorrect Direction on the hull surface

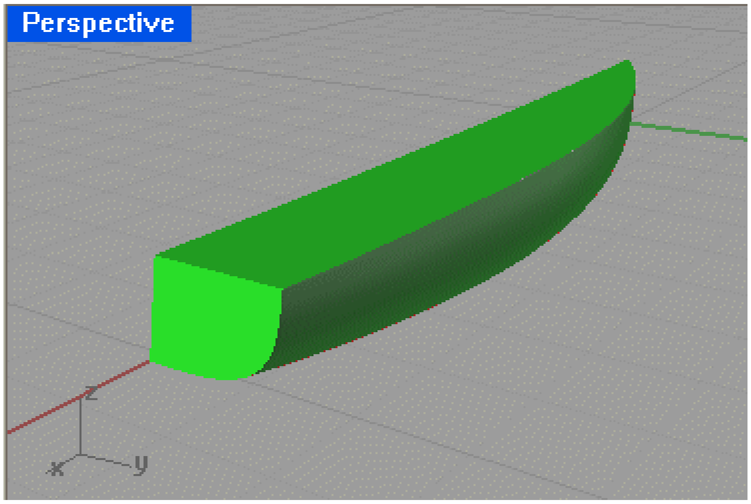


Direction corrected with the Flip option

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. 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. In the example below, the surface color is set to green, and the backface color is set to red.



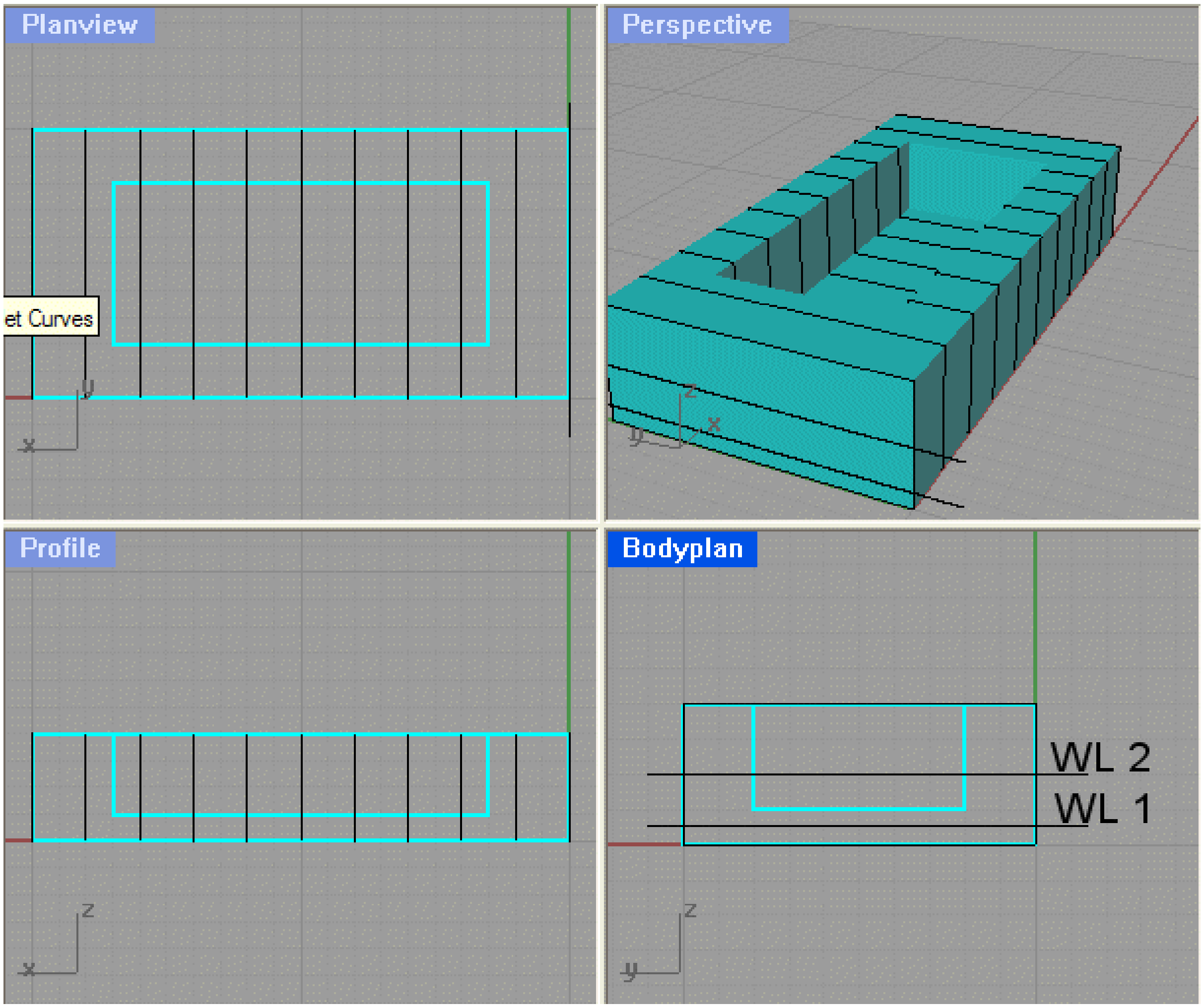
Incorrect Direction on the transom surface



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.

9.3 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 the following combinations:

Weight, LCG, TCG

Weight, LCG, Heel

Weight, Trim, TCG

Weight, Trim, Heel

Model Sinkage , Trim, Heel

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.

Weight: the overall weight of the vessel, in the units shown

LCG: the longitudinal center of gravity of the vessel, in the current length units, from the world origin

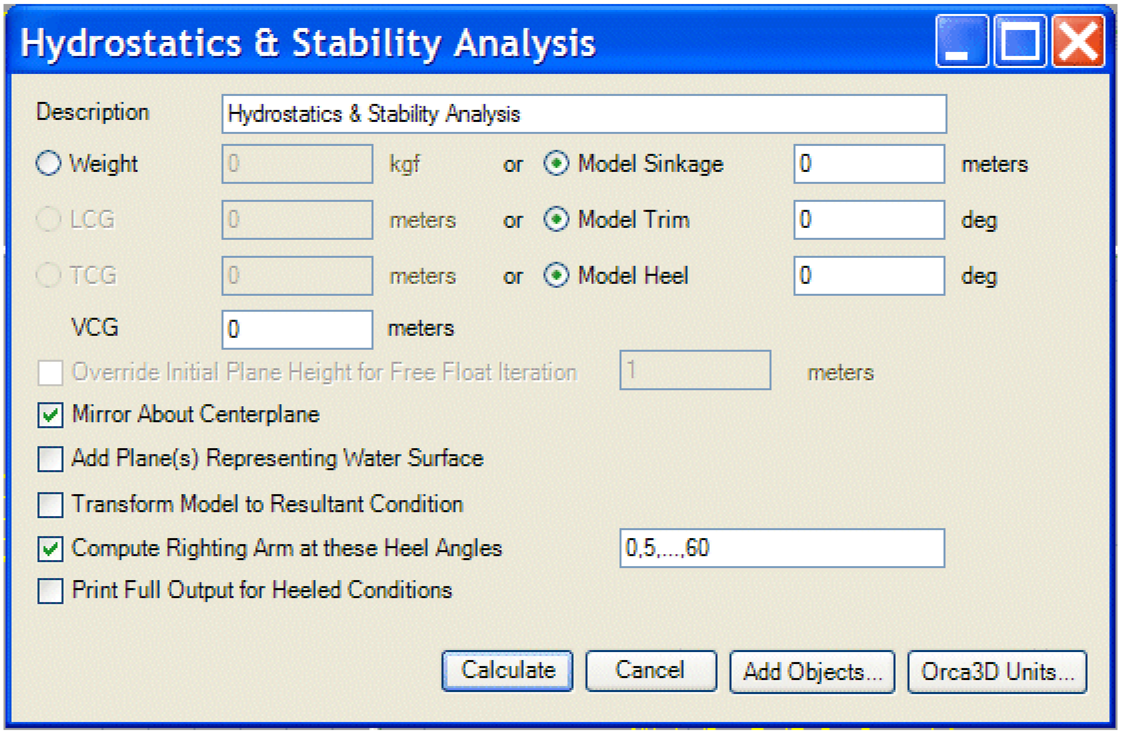
TCG: the transverse center of gravity of the vessel, in the current length units, from the world origin

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)

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 X is aft, positive Y to starboard, and positive Z is up, 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, positive Y to starboard, and positive Z is up, a positive heel angle is to port

Model Sinkage: the distance along the vertical axis from the world origin to the waterplane, in the current length units



Optional Inputs

Description: This field will be included in the output for the analysis

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

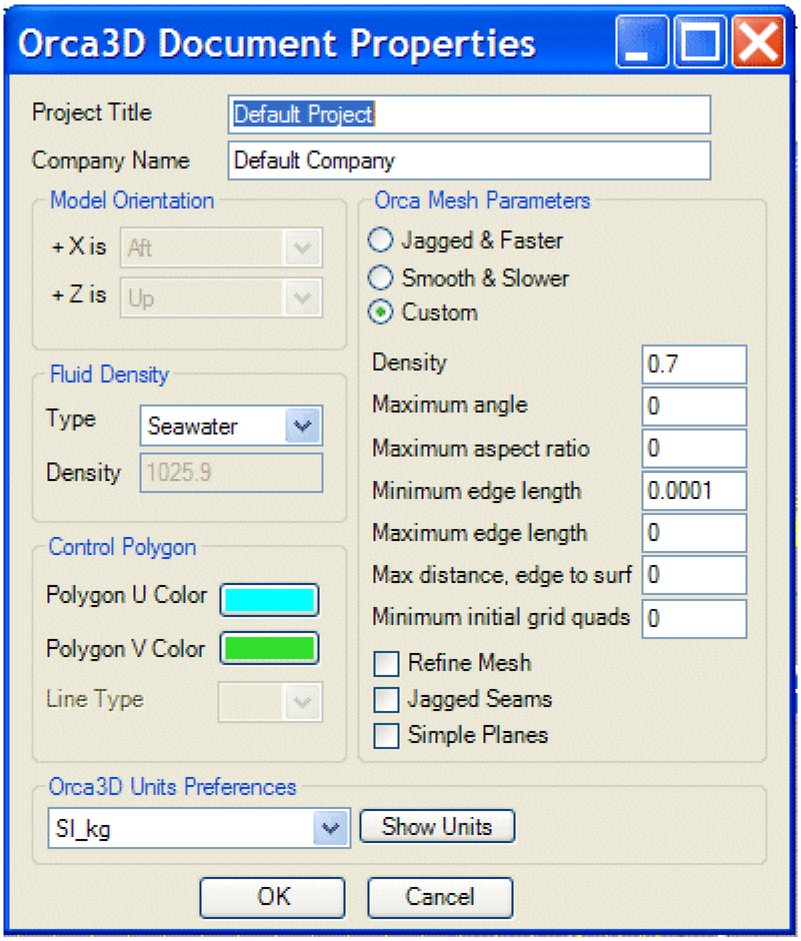
Transform Model to Resultant Condition: This option will cause the model to be moved (only that portion of the Rhino model that was selected for the hydrostatics calculation). The model is first heeled about the world longitudinal axis, then trimmed about the world transverse axis, then sunk along the world vertical axis.

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, ...,c where a is the first angle, c is the final angle, and intermediate angles will be included at a spacing of (b-a).

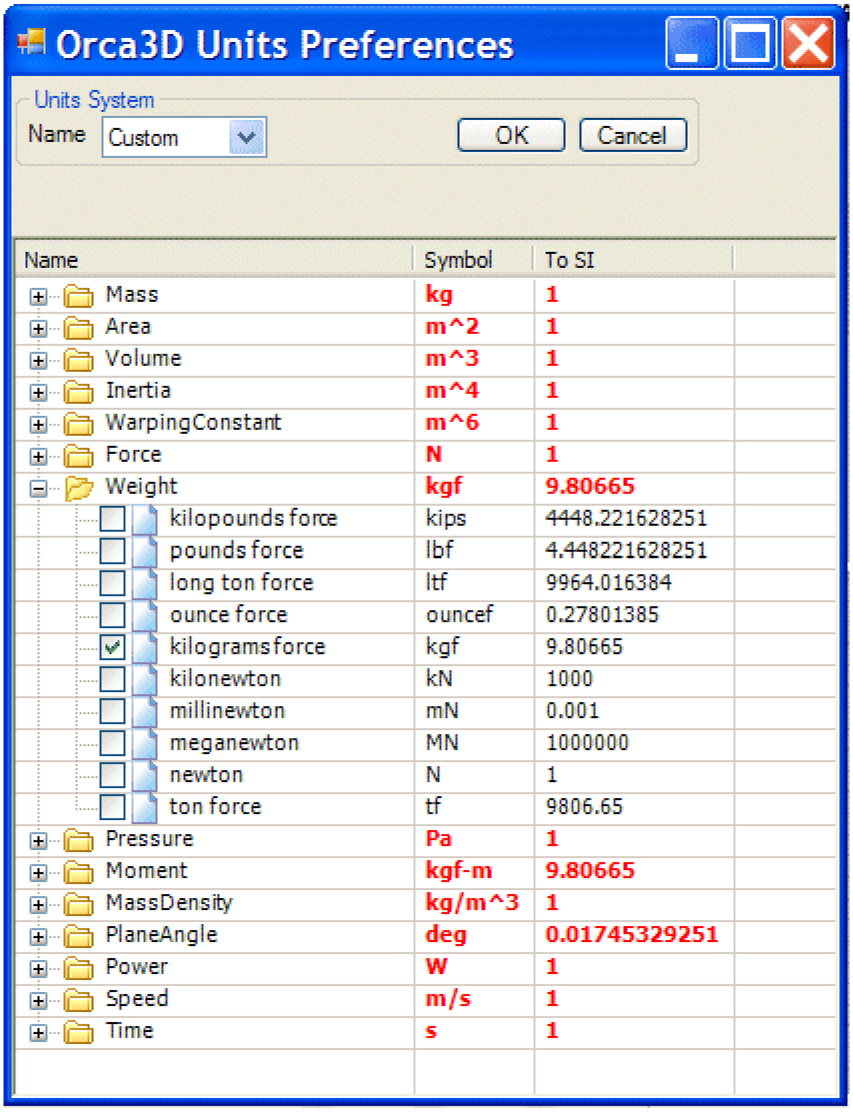
Print Full Output for Heeled Conditions: By default, the output does not include a complete table of hydrostatic data at each heeled condition. Checking this box will cause the complete hydrostatic data to be included in the report for each heel angle.

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:



You may choose from four pre-defined Orca3D Unit Preferences: SI-kg, SI-tonne, Imperial-lbs, Imperial-LT, or you may 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. Once in the Orca3D Units dialog, select "Custom" as the Units Sytem. Each of the unit types displays its current value, and may be expanded in the tree to show the selection of options.



9.4 Design Hydrostatics

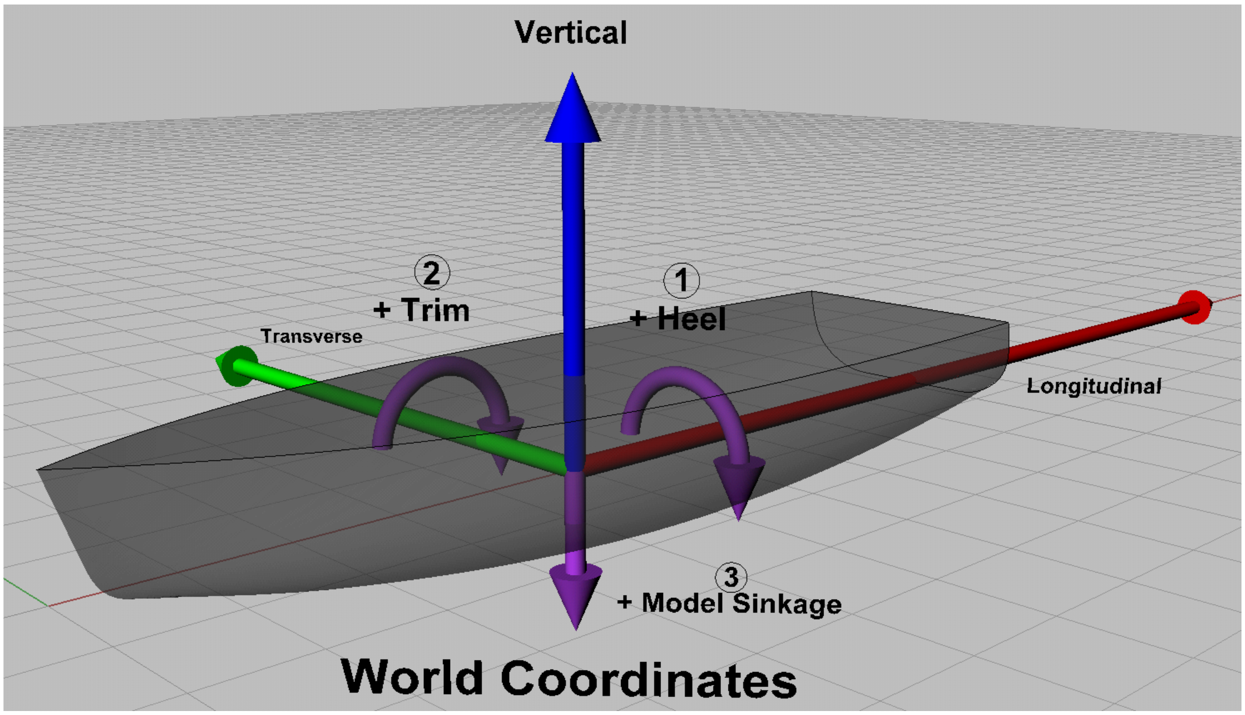
Orca3D can compute hydrostatics and stability in various combinations of waterplanes/ displacement and center of gravity/heel/trim, with a range of heel angles. However, while you are fairing a hull, you are usually just interested in the hydrostatics at the "design waterline," or at a particular displacement/center of gravity.

In Orca3D, there is 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.

For complete information, please see the Design Hydrostatics 42 topic in the Quick Start Tutorials section.

9.5 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 with positive sinkage defined in the negative vertical direction (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) 107 section.



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 and model trim or LCG and model heel or TCG.

Weight: the overall weight of the model in the specified fluid density, in the units shown

Model Sinkage: the distance along the vertical axis from the world origin to the waterplane, in the units shown. Positive sinkage is defined in the negative vertical direction of the world coordinates.

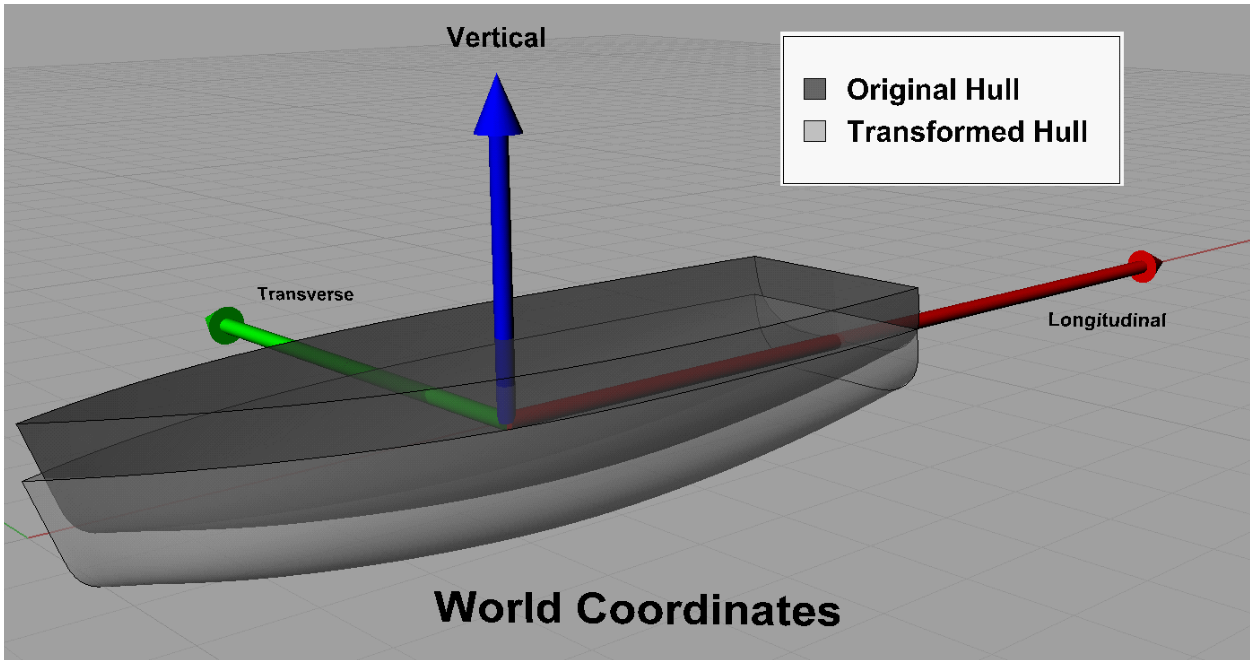


Figure 1.4 Model Positive Sinkage of 0.5 Meters

Model Trim: the trim angle of the vessel, in degrees from the horizontal plane in the world coordinates. A right-hand coordinate system 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.

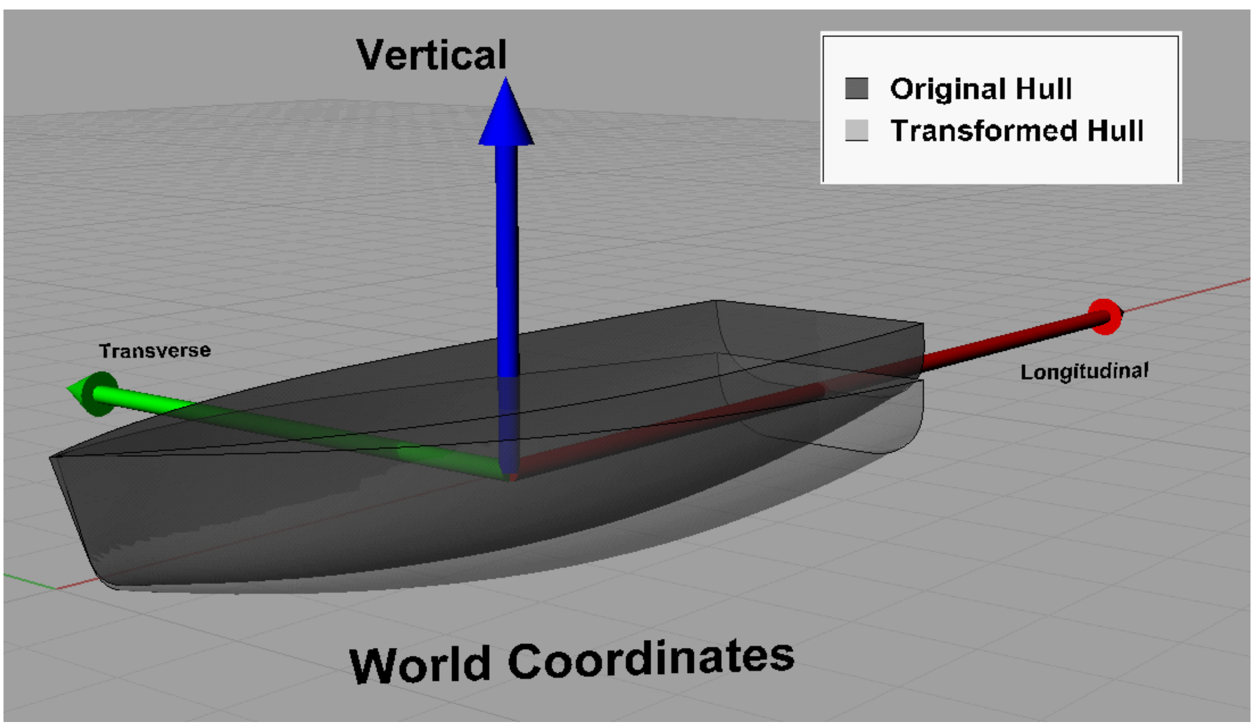


Figure 1.3 Model Trimmed Positive 3.5 Degrees

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 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.

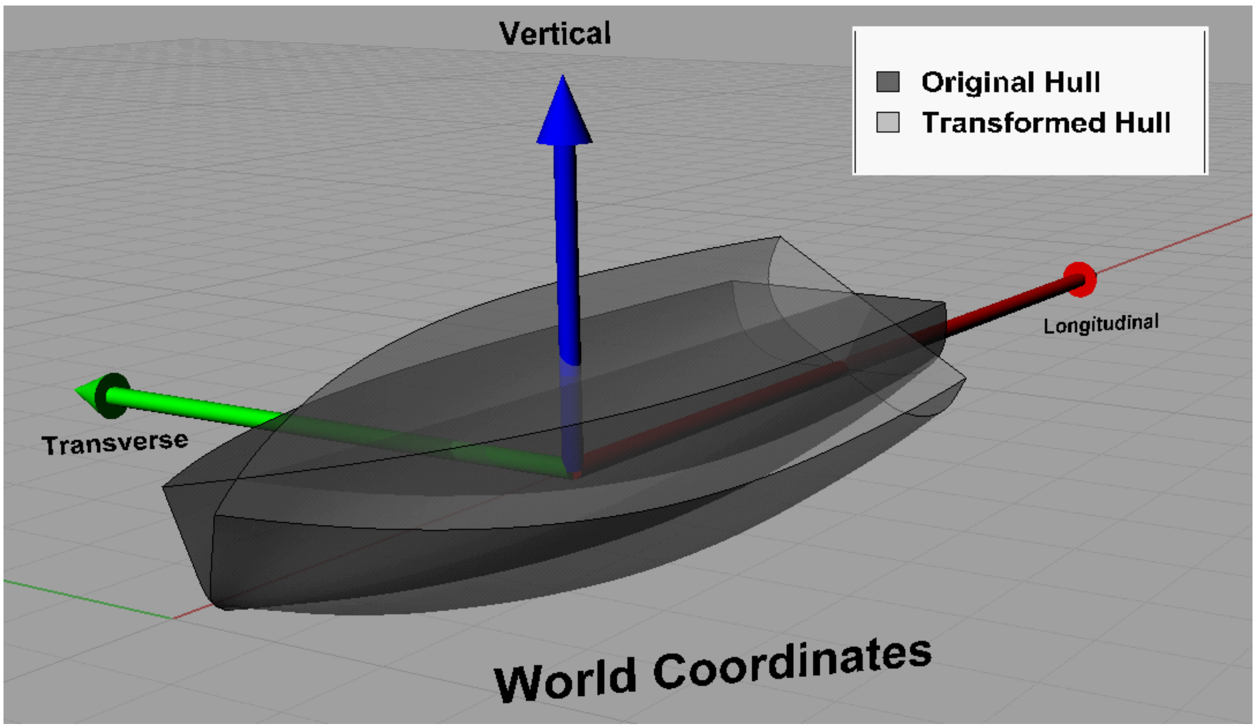


Figure 1.2 Model Heeled Positive 30 Degrees

TCG: the transverse center of gravity of the vessel, in the units shown measured from the world origin

Resulting Model Attitude and Hydrostatic Properties

The resulting model orientation and calculated hydrostatic properties for each defined flotation condition(s).

Sinkage: the distance, in the units shown, the vessel waterplane has moved from the world origin in the vertical direction resulting from the defined flotation condition. Positive sinkage is defined in the negative vertical direction.

Trim: the resultant trim angle, in degrees, of the vessel from the horizontal plane in the world coordinates resulting from the defined flotation condition.

Heel: the resultant heel angle, in degrees, of the vessel from the horizontal plane in the world coordinates resulting from the defined flotation condition.

Ax: the maximum underwater sectional area calculated using Orca sections, in the units shown. If no Orca sections are specified, this value will be 0.

Displacement: the overall weight of the vessel, in the units shown, as defined in the input or calculated from the defined flotation condition.

LCB: the longitudinal center of buoyancy of the resultant model orientation in the units shown from the world origin.

TCB: the transverse center of buoyancy of the resultant model orientation in the units shown from the world origin.

VCB: the vertical center of buoyancy of the resultant model orientation in the units shown from the world origin.

Wet Area: the area, in the units shown, of the underwater surfaces selected for the hydrostatic & stability analysis.

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 from the world origin.

TCF: the transverse center of flotation of the resultant model orientation in the units shown from the world origin.

VCF: the vertical center of flotation of the resultant model orientation in the units shown from the world origin.

BMt: the transverse metacentric radius in the units shown of the resultant model orientation

BMl: the longitudinal metacentric radius in the units shown of the resultant model orientation

GMt: the transverse metacentric height in the units shown of the resultant model orientation

GMl: the longitudinal metacentric height in the units shown of the resultant model orientation

Cb: the block coefficient of the resultant model orientation due to the defined flotation condition

Cp: the prismatic coefficient of the resultant model orientation. If no Orca sections are defined, this will be 0.

Cwp: the waterplane coefficient of the resultant model orientation.

Cx: the maximum section coefficient of the resultant model orientation interpolated using section data. If no Orca sections are defined, this will be 0.

Cws: the wetted surface coefficient of the resultant model orientation.

Cvp: the vertical prismatic coefficient of the resultant model orientation.

Volumetric Properties

The displacements and centers, in the units shown, plotted for each draft(s) defined from the load condition(s).

Area Properties

The areas and centers, in the units shown, plotted for each draft(s) defined from the load condition(s).

Hull Form Coefficients

The hull form coefficients plotted for each draft(s) defined from the load condition(s).

Surface Meshing Parameters

These values define the mesh settings for the model. They can be changed in the Orca3D Document Properties dialog box.

Density: Rhino uses a formula to control how close the polygon edges are to the original surface. Values between 0 and 1. Larger values result in a mesh with a higher polygon count. The default value in Orca3D is 0.7.

Maximum Angle: the maximum allowable change between the surface normal at any point and the mesh vertex. The default value in Orca3D is 0.7.

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 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 false.

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: polygons divide until the distance from a polygon edge midpoint to the NURBS surface is smaller than this value. The default value in Orca3D is 0, which turns off this option.

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.

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 false.

Load Condition Parameters

The load condition parameters and resultant model attitude are shown again for each load condition. Here the fluid type and fluid density are displayed in the units shown.

Overall Dimensions

The overall vessel dimensions of length, beam, and depth are displayed in the units shown as well as the ratios of length overall to beam overall and beam overall to depth.

Waterline Dimensions

The vessel waterline dimensions at the defined load conditions in the units shown. The ratios of waterline length to waterline beam, waterline beam to draft, and depth to draft are shown as well. Note that the dimensions are the maximum dimensions; if your vessel is a catamaran, the Waterline Beam will be the distance from the outer edge of the port hull to the outer edge of the starboard hull.

Volumetric Values

The parameters defining the underwater volume of the vessel in the defined load condition. These include the vessel displacement, underwater volume, the centers of buoyancy, and wetted surface area. The ratio of LCB to LWL is measured from the bow; a value less than 0.5 means that the LCB is forward of the midpoint of LWL.

Waterplane Values

The parameters defining the waterplane of the vessel in the defined load condition. These include the waterplane area and centers of flotation of the vessel. The ratio of LCF to LWL is measured from the bow; a value less than 0.5 means that the LCF is forward of the midpoint of LWL.

Sectional Parameters

The maximum cross sectional area, in the units shown, is defined with its location measured from the world origin in the units shown. If no Orca stations are defined, these values will be 0.

Hull Form Coefficients

The hull form coefficients are shown for the defined load condition.

Static Stability Parameters

The static stability parameters are shown for the defined load condition including the transverse and longitudinal area moments of inertia in the units shown.

Station Data

If Orca stations are defined, a plot of the immersed area and wetted girth versus station location is displayed. A table of station location, measured from the world 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, 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.

Part X

10 Speed/Power Analysis

Orca3D contains methods from the HydroComp Drag Prediction Library for predicting the resistance of hulls.

The HydroComp Drag Prediction Library v2 is a calculation engine for the prediction of bare-hull drag. Two prediction methods are available - **Savitsky** (planing hulls) and **Holtrop** (displacement or semi-displacement hulls).

The methodology employed in the library for the prediction of bare-hull drag must initially be determined in the context of the vessel's principal hull form. Marine craft follow a number of different physical principles to support and move the mass of the hull through the water. Each vessel's basic motion is useful in defining the technique that is most appropriate to predict its bare-hull resistance.

A vessel can typically be categorized by the way the hull is vertically supported while in motion (lift), which in turn points to a particular methodology for the lateral resistance to motion (drag). If a hull's lift is entirely supported by hydrostatic buoyant forces and its drag is horizontal, it has traditionally been known as a "displacement" hull. For the purposes of drag prediction, however, we call it a ***C_T-based hull*** (due to the numerical calculation formats). A craft principally supported by hydrodynamic bottom pressures is called a ***Planing hull***. Hulls operating in an intermediate regime are traditionally known as "semi-displacement", "semi-planing" or "pre-planing".

Resistance methodologies for the two principal categories – C_T-based (for displacement and semi-displacement hulls) and Planing – have seen much development over the years, but the most useful approaches generally fall into one of two forms – a geosim drag coefficient (C_T) method for C_T-based hulls, and an equilibrium state Planing hull technique.

It is important to mention that both of these methodologies have evolved over the years, particularly with respect to the prediction of viscous (frictional) drag and model-to-ship correlations. As techniques change, however, it is common to see older corrections improperly applied to newer techniques, and the accuracy of the results has suffered. In other words, all parts of the process must be compatible to be successful. With this in mind, the drag prediction methods in the library reflect contemporary thought, as well as corrections and improvements to the behavior and accuracy of the methods.

10.1 Planing Hull Savitsky Prediction

10.1.1 Introduction

Planing hull drag prediction using the Savitsky method

Planing is a hydrodynamic state where a hull is dynamically supported by pressures that are developed by the forward motion of the vessel. Before addressing the state of planing, let's consider what a boat needs to do before getting up on plane.

At rest, a hull is supported by buoyancy. The static water pressure surrounding the hull holds it in place. This hydrostatic state is completely a function of the hull's volumetric shape.

When a boat begins to move, however, it forces water around and under the hull and it is no longer in a hydrostatic state. It is now in hydrodynamic motion. As a boat moves at low speeds, the water typically follows flow lines that return more-or-less to their original position behind the hull. This is traditionally called the displacement hull mode.

The boat accelerates as a we give it more throttle into what is called the semi-displacement or pre-planing modes. In this mode it will also tend to sink a bit and trim up by the bow due to suction forces at the stern. The boat is now approaching the hump, that point where the sinkage and trim are greatest.

The trim that is inherent in this mode gives us the critical piece that allows for planing to occur. The suction that previously pulled the stern down now turns to a pressure as the boat runs faster and faster. The pressure - caused by the motion of the hull through the water at a particular angle of attack (its trim) - begins to lift the hull and typically reduce the trim somewhat. The final state of lift and trim is a complex equilibrium of forces and moments. The boat will remain in this state so long as nothing changes its speed, trim or weight distribution. The boat is now fully planing, or on plane.

Components of planing hull drag

The planing hull equilibrium described above shows us that trim and lift are interrelated. Trim affects lift, and it also affects drag. In fact, trim determines drag, as we will see below.

(Note: This describes the drag on the hull only. A boat in service will have additional drags due to appendages, seas, and shallow water. It might also have devices such as trim tabs that will also affect drag. These are not treated here.)

Planing hull drag is made up of four principle components:

Pressure + Friction + Spray + Windage

Windage drag is the air resistance of the exposed hull that is driven through the air. It has the tendency to increase trim. More windage area means more drag and also more trim.

Spray drag, sometimes called whisker spray, is the drag of the hull driving through the mass of the spray that is produced ahead of the boat. Evaluating the effect of spray is complicated and is often neglected, as well-designed spray rails or strakes can be effective in moving the spray away from the hull rather than leaving it in front of the hull. Like windage drag, spray drag would contribute to greater drag and trim.

This leaves Pressure drag and Friction drag as the two parts of our planing drag analysis. The planing hull analysis that is used here is a modified version of the well-known Savitsky prediction method.

Savitsky prediction method

The Savitsky method poses the bare-hull planing drag as

$$\text{Bare-hull drag} = \text{Pressure} + \text{Friction} = L \tan(\tau) + C_F \tfrac{1}{2} \rho S V^2 / \cos(\tau)$$

where,

L = lift on the planing bottom (nominally the boat weight)

τ = dynamic trim angle

C_F = frictional drag coefficient across the wetted planing surface

ρ = mass density of the water

S = wetted planing surface area at the particular dynamic trim angle

V = mean water velocity across the wetted planing surface

The Savitsky prediction calculations solve for all of the above variables at a given trim angle. The prediction, therefore, must solve for the proper trim angle so that the equilibrium is maintained.

This implementation of a Savitsky prediction includes the effect of the boat's CG location (as it is about this point where the equilibrium is centered), as well as the thrust line vector. For example, a thrust line that is pointed above the CG will tend to lower trim, while a vector below the CG will bring the bow up.

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. HydroComp has developed and implemented a number of modifications to the Savitsky method for warped hulls, as well as for hulls of non-linear sections with strakes and rails.

Evaluating drag at pre-planing speeds

The methodology described above is for a boat past the hump and settled into its fully planing hydrodynamic mode. The calculations employ a version of the Blount/Fox pre-planing hump speed correction to better model the shape of the drag curve at pre-planing speeds.

Differences in Savitsky methods

You must not expect that all calculations built upon the basic Savitsky formula to produce the same prediction results. Some reasons for this are:

- **Use of an equilibrium trim analysis.** Some predictions do not consider the effect of the lift and drag components on trim. For example, if the thrust line vector is assumed to pass through the CG (which Savitsky called the simple case), the predicted trim and drag will not account for this.

- **Definition of deadrise angle.** Unfortunately, there is no standard rule for the calculation of appropriate deadrise angle. Differences in how the deadrise is calculated produce differences in the prediction results.

- **Definition of the chine beam.** The outer chine beam defines the shape of the wetted planing surface. A different beam gives a different result.

- **Variable deadrise.** Warped hulls of varying deadrise need a dynamic calculation of a suitable effective deadrise.

This implementation of the Savitsky prediction accounts for all of these variables.

Drag reduction analysis

This planing hull analysis also provides design feedback. Four hydrodynamically significant hull parameters - deadrise, LCG, thrust line shaft angle, and chine beam - are evaluated for their effect on drag. A sensitivity index number provides a measure of the significance of the parameter on drag. By reviewing the indices, you can see a measure of the parameter's influence on drag and then use this information to optimize your designs.

References

The following are three important references about the Savitsky prediction methodology.

- 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.

About effective power

Effective power is a function of resistance. It is simply resistance converted to power units by multiplying by the boat's speed.

Effective power = Resistance * Speed

Effective power is NOT engine power, as only a fraction of the engine's rotational energy can be converted into thrust at the propeller. Between engine power (at the engine) and effective power (at the hull) are a number of places where energy is lost. These losses can be defined by individual efficiencies:

Transmission efficiency = 96% to 98% (gear friction and heat)

Shafting efficiency = 97% to 98% (bearing friction and shaft torsion)

Hull efficiency = 90% to 100% (pressure regions affecting the hull)

Propeller efficiency = 50% to 70% (hydrodynamic losses)

Multiplying these together gives us the ratio of effective-to-engine power. This figure is known as the *Overall Propulsive Coefficient*, or *OPC*. OPC varies with hull type, speed range and propeller style, and is typically in the range of 50% to 65%. Some applications can push the OPC to 70%, while heavily loaded, slower hulls can see OPC reduced to 40% or less.

Estimating engine power

As we can see from the effective-to-engine power figures of 50% to 65%, your engine power is likely to be in the range of twice your effective power – sometime more. To estimate engine power, you can use the following table to find a multiplier to estimate engine power from the predicted effective power.

First, remember that the predicted effective power is for the bare hull only. You will need to add an appropriate *service margin* for additional hull roughness, appendages, windage, and seas. So, match service margin and OPC to find an engine power multiplier.

Table of engine-to-effective power multipliers

Service margin

		0%	10%	20%	30%
OPC	50%	2.00	2.20	2.40	2.60
	55%	1.82	2.00	2.18	2.36
	60%	1.66	1.83	2.00	2.17
	65%	1.54	1.69	1.85	2.00

Please note, however, that a reliable estimate of service margin and OPC requires a thorough propulsion analysis, which is beyond the scope of these calculations. Before selecting an engine for your design, we strongly recommend that you prepare a proper propulsion analysis, either by consulting with an experienced professional or with comprehensive propulsion analysis software.

10.1.2 Model Requirements

It is critical to satisfy various requirements for the model when running the Planing Hull Savitsky Prediction. These are:

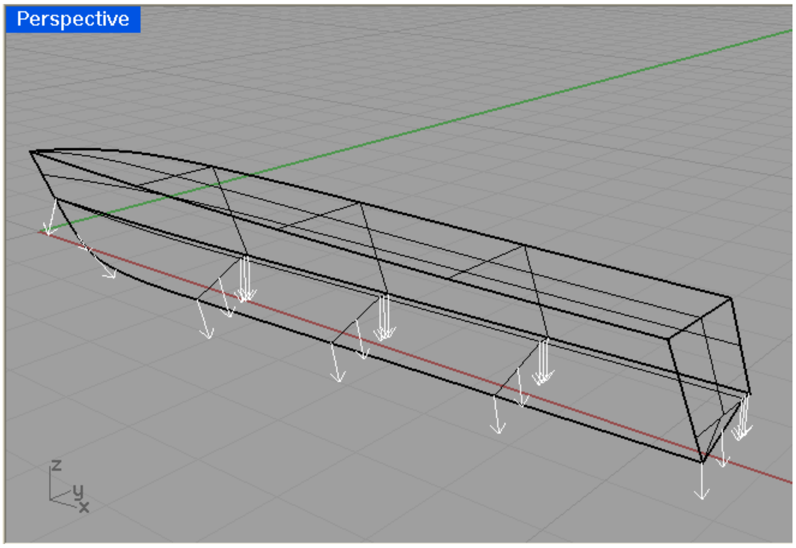
- **MUST ONLY represent the planing surface up to the chine; a hull surface that includes the topsides can be split at the chine by selecting the surface, then selecting the Surface menu > Surface Edit Tools > Split at Isocurve, finally selecting the curve representing the chine and press Enter**

- **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)

- **MUST be oriented with forward in the negative X-direction and up in the positive Z-direction**

- **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.

- 

10.1.3 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**

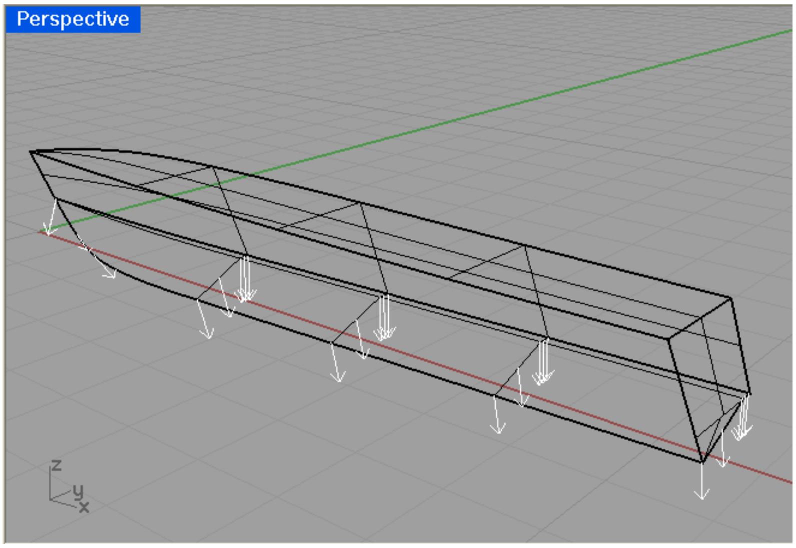
   - **MUST ONLY represent half of the hull**

   - **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)

   - **MUST be oriented with forward in the negative X-direction and up in the**

positive Z-direction

- **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.
   - 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.

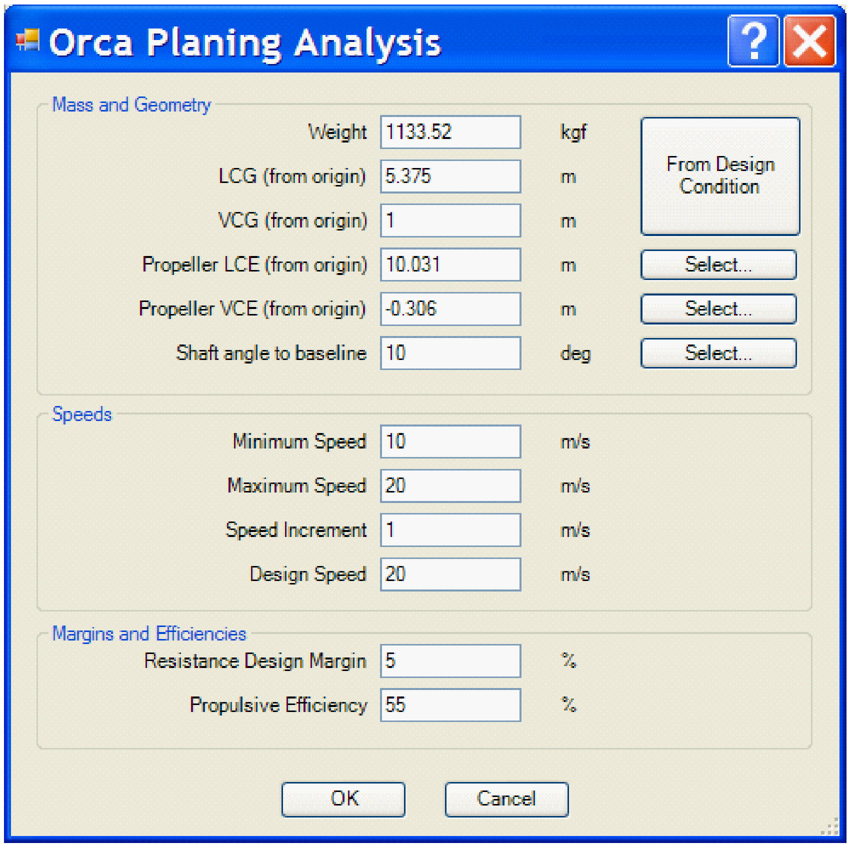
Splitting a Surface

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.



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 *Select…* button next to each input box.

Speeds

Enter the minimum speed, maximum speed, increment speed, and design speed of the vessel 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.

10.1.4 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.

DesignSpeed: the user-defined “operational” speed of the vessel. This speed is used in the drag reduction sensitivity analysis.

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.

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.

LCGPerBch: 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 design 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 Fnv = Speed/(g*DisplacedVolume?)½

Trim (deg): the predicted trim of the vessel at the corresponding speed.

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

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.

FnBch: 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.

Eff Deadrise (deg): the calculated effective angle of deadrise of the wetted planing area.

Rbare/W: the ratio of the predicted bare hull resistance to the bare hull weight at the corresponding speed.

Porpoising: the projected porpoising stability of the vessel: Stable, Unstable or Check.

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.

Sensitivity Analysis

The report provides a sensitivity analysis to reduce drag performed at the design speed. A sensitivity index with a higher value has a greater influence on drag. A value greater than 1.0 is considered significant. The third column of the table indicates if the value should be increased or decreased to reduce drag.

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.

10.2 Ct-based Holtrop Prediction

10.2.1 Introduction

C_T-based drag prediction using the Holtrop method

At low speeds (pre-planing), a vessel is principally supported by buoyancy, with no significant sinkage or trimming. As the boat moves, the water typically follows flow lines that return more-or-less to their original position behind the hull. This is traditionally called the displacement hull mode.

The drag of a boat in this mode is considered to be fully horizontal and opposite to the direction of motion. Two principal types of drag make up the total - viscous (surface friction) and wave-making (mass movement). The viscous drag relates to the characteristics of the form of surface area, including its boundary layer thickness, surface roughness, and water viscosity. The wave-making drag, on the other hand, most directly relates to volumetric shape and the energy lost by moving a mass of the water away from where it started and back again. Each must be addressed to fully describe the total bare-hull drag.

Components of C_T-based drag analysis

One of the basic tenets of hydrodynamics is that the drag of a vessel immersed in a fluid is related to the dynamic pressure surrounding the body. This pressure is defined by the well known Bernoulli equation, which is the foundation of a system of coefficients used to define resistance in a non-dimensional form. By adding a term representing the square of the ship dimension (the wetted surface area), pressure is converted into drag (a force) and the equation looks like:

$$C_T = R_T \,/\, ½\, \rho\, S\, V^2$$

where,

C_T = resistance coefficient

R_T = resistance

ρ = mass density of water

S = wetted surface

V = ship velocity

The initial use of this methodology is very old. In the latter-1800s, William Froude used this relationship to establish the fundamentals of correlating resistance between ships, and eventually from models to ships. This technique is only truly appropriate when comparing hulls that are geosims (i.e., geometrically similar).

However, the above relationship made resistance non-dimensional, and Froude added a relationship for what he called the corresponding speed [Froude, 1888], which he deemed was what controlled the wave-making system. In this methodology, ship speed corresponds to the square root of its length. A non-dimensional coefficient for this corresponding speed now bears his name – the Froude number.

The first usage of these coefficients plotted the coefficient of total resistance (C_T) versus Froude number. Froude ultimately determined that the total resistance must be divided into a viscous component and a wave-making component, since the viscous component is a function of speed, water viscosity and wetted surface, while the wave-making component depends principally upon speed, water density and displacement. The component terms for these two parts were frictional (C_F) and residuary (C_R) – so named to represent all resistance over-and-above frictional. This system has been the root of all for C_T-based prediction methods for over 100 years.

Contemporary updates to the Froude methodology

The division of the total drag into frictional and residuary is known as a two-dimensional analysis, since the viscous component is solely made up of skin friction (on the 2D wetted surface). The corresponding residuary resistance includes not only the wave-making system energies, but also eddy and viscous energy losses due to the hull form. Research throughout the latter-1900's has suggested that the two-dimensional analysis does not adequately reflect the contribution of hull shape to viscous drag.

In answer to this deficiency, a contemporary derivative of the 2D analysis shifts the viscous drag effects of the hull shape (C_{FORM}) to the total viscous drag (C_V), isolating the true wave-making drag (C_W) component. This is called a three-dimensional analysis.

In the three-dimensional scheme put forth by the ITTC in 1978, the viscous coefficient (C_V) is defined as $C_V = (1+k)\ C_F$, where the term *1+k* is the "form factor" that accounts for the three-dimensional effects. Therefore, the form coefficient (C_{FORM}) is then defined as $C_{FORM} = k * C_F$. This format is the organizational basis used by the Holtrop prediction method.

Holtrop prediction method

The Holtrop method follows the ITTC-1978 approach to pose the bare-hull drag as

Bare-hull drag = Viscous + Wave-making

The wave-making drag is derived from a speed-dependent relationship using the Havelock wave shape as its foundation. The basis for the use of the Havelock theory is currently out of favor, as a speed-dependent analysis like Havelock has trouble matching the typical humps and hollows of the drag curve below the principal wave-making hump (which generally occurs at a Froude number near 0.4).

Corrections and additions for bulbous bows and immersed transom sterns were eventually added to this Havelock theory wave-making drag, resulting in the current Holtrop method, as

Bare-hull drag = Viscous + Wave-making + Bulb pressure + Transom pressure

One important consideration when using the Holtrop method is that it was developed with a particular set of hull data. Hulls that are outside of the scope of the data set can lead to predictions that are significantly incorrect. HydroComp has developed and implemented a number of modifications to the published Holtrop method to help insure that results are as well-behaved and accurate as possible.

Differences in Holtrop methods

You must not expect that all calculations built upon the published Holtrop formula will produce the same prediction results. Some reasons for this are:

- **Form factor.** The C_T-based methodology uses wetted surface to describe the size of the vessel. The true dynamic wetted surface would be the most precise approach (as is used in the planing analysis, for example), but the measurement of the wetted surface on a moving model is not easy, so the at-rest wetted surface is typically used as the datum value. This can lead to a somewhat incorrect contribution of the various applied resistance components, and in turn to inaccurate extrapolation of the model results to full scale, particularly at higher speeds. This version includes a speed-dependent form factor correction to address this problem. The correction applies a slight increase in form drag at Fn of about 0.3 and the correction diminishes at about 0.6 Fn. This is consistent with observations from high-speed testing.

- **Estimated data.** The Holtrop method uses data for which there may be no standard quantifiable definition of measurement, such as half-angle of entrance and stern coefficient. HydroComp has conducted studies to establish standards that do provide a consistent measure for the parameter.

- **Boundary constraints.** Certain Holtrop method calculation coefficients and parameters can introduce significant errors for particular combinations of hull data, and may be quite sensitive to combinations of hull parameters. Many years of internal review and re-analysis have gone in to the development of checks to insure that these coefficients are well-behaved. This means that, in some cases, upper or lower constraints may be applied to the coefficient or parameter, and the result may be different from the published formula without these checks.

- **Publication differences and errors.** There are five different published technical reports over an eleven-year period presenting the different evolutions of the Holtrop prediction method. The principal source is the 1984 publication, although the 1982 publication (Holtrop & Mennen) is also frequently cited. The formula are different between publications, so of course the prediction results will also be different. The references have also been reprinted in other books and journals, and it has been found that some of these are printed incorrectly.

This implementation of the Holtrop prediction method accounts for all of the above.

Drag reduction analysis

This C_T-based analysis also provides design feedback. Four hydrodynamically significant hull parameters - maximum section area, waterplane area, immersed transom area, and LCB - are evaluated for their effect on drag. A sensitivity index number provides a measure of the significance of the parameter on drag. By reviewing the indices, you can see a measure of the parameter's influence on drag and then use this information to optimize your designs.

References

The following are important references about the Holtrop prediction method and C_T-based analysis.

- Holtrop, J., "A Statistical Re-Analysis of Resistance and Propulsion Data", *International Shipbuilding Progress*, Vol. 31, No. 363, November 1984.

- Holtrop, J. and Mennen, G.G.J., "An Approximate Power Prediction Method", *International Shipbuilding Progress*, Vol. 29, No. 335, July 1982.

- ITTC, *Proceedings of the 15th ITTC*, The Hague, The Netherlands, published by the Netherlands Ship Model Basin, Wageningen, 1978.

About effective power

Effective power is a function of resistance. It is simply resistance converted to power units by multiplying by the boat's speed.

Effective power = Resistance * Speed

Effective power is NOT engine power, as only a fraction of the engine's rotational energy can be converted into thrust at the propeller. Between engine power (at the engine) and effective power (at the hull) are a number of places where energy is lost. These losses can be defined by individual efficiencies:

Transmission efficiency = 96% to 98% (gear friction and heat)

Shafting efficiency = 97% to 98% (bearing friction and shaft torsion)

Hull efficiency = 90% to 100% (pressure regions affecting the hull)

Propeller efficiency = 50% to 70% (hydrodynamic losses)

Multiplying these together gives us the ratio of effective-to-engine power. This figure is known as the *Overall Propulsive Coefficient*, or *OPC*. OPC varies with hull type, speed range and propeller style, and is typically in the range of 50% to 65%. Some applications can push the OPC to 70%, while heavily loaded, slower hulls can see OPC reduced to 40% or less.

Estimating engine power

As we can see from the effective-to-engine power figures of 50% to 65%, your engine power is likely to be in the range of twice your effective power – sometime more. To estimate engine power, you can use the following table to find a multiplier to estimate engine power from the predicted effective power.

First, remember that the predicted effective power is for the bare hull only. You will need to add an appropriate *service margin* for additional hull roughness, appendages, windage, and seas. So, match service margin and OPC to find an engine power multiplier.

Table of engine-to-effective power multipliers

		Service margin			
		0%	10%	20%	30%
OPC	50%	2.00	2.20	2.40	2.60
	55%	1.82	2.00	2.18	2.36
	60%	1.66	1.83	2.00	2.17
	65%	1.54	1.69	1.85	2.00

Please note, however, that a reliable estimate of service margin and OPC requires a thorough propulsion analysis, which is beyond the scope of these calculations. Before selecting an engine for your design, we strongly recommend that you prepare a proper propulsion analysis, either by consulting with an experienced professional or with comprehensive propulsion analysis software.

10.2.2 Model Requirements

10.2.3 Computing Resistance

10.2.4 Output

Part XI

11 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.

11.1 General Questions

- **What are the requirements to run Orca3D?** 139
- **Why is Rhino required?** 139
- **Where can I get help with questions or problems?** 139

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. Specific requirements:

- Rhino Version 4, SR 3 or higher
- Hardware: See Rhino hardware requirements
- Operating Systems tested: Windows XP, Vista
- Operating Systems not tested: Windows 2000, 64-bit XP
- Operating Systems not supported: Windows ME, 98, 95, NT
- Mac: The Intel Mac with Bootcamp or Parallels has not been tested
- Microsoft .NET (the Orca3D installation will install it if it is not already on your computer)
- Valid license key (without this, Orca3D will operate as a 30-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 Support page for details. If you cannot find an answer to your question there, please send an email to support@orca3d.com.

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11.2 Licensing Questions

My trial period has ended. How do I get a license?

The trial period is a 15-day, fully-functional evaluation license. If you feel that you need more time to evaluate the software before purchasing, please contact us. If you're ready to purchase, please visit our Order web page.

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?

Refer to the section entitled "Moving a License to Another Computer 157".

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?

Contact us with details of the situation, and we will enable your license for another activation.

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11.3 Hull Design & Fairing

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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11.4 Hydrostatics & Stability

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 XII

12 Licensing

Orca3D uses a software-based tool to manage your license. This prevents unauthorized use of the software, but is as flexible as possible to allow you to quickly and easily license your copy of Orca3d, modify your license (to add modules, for example), and move your license easily to another computer.

Orca3D includes a utility to allow you to manage licenses installed on your PC. When Orca3D is installed, you can run the Orca3D License Manager:

The License Manager utility allows you to control your license using both offline and activation methods.

With this utility you can:

1. Check the status of a license;
2. Activate via the Internet, via two methods to suit your setup;
3. Call or E-mail your license to get an Unlocking Code;
4. De-Activate and Re-Activate your PC via the Internet when moving Orca3D from one computer to another;
5. Manually move licenses to a new computer using removable storage such as floppies, USB Flash/Zip Drives, Mapped Network Drives, etc.;
6. Produce an Installation ID that will be used by us to allow for the changing and/or updating of the license parameters on your computer;

7. Permanently remove a license and receive a code to prove it.

To start the License Manager, click on the Windows START button and navigate to the Orca3D folder, then click on the License Manager Utility.

See also:

FAQ-Licensing 140

12.1 The "Short Version"

Orca3D's licensing system is very flexible, and there may come a time when you need to move, upgrade, or return a license. But for the most part, you just want to install, purchase, and license the software, and get on with your work. The following describes the simple process of doing just that. If you need more detail or cannot activate automatically via the internet, please read through the remainder of this chapter.

Here are the steps (note that Steps 1 and 2 are reversible):

Step 1: Download and Install the Software

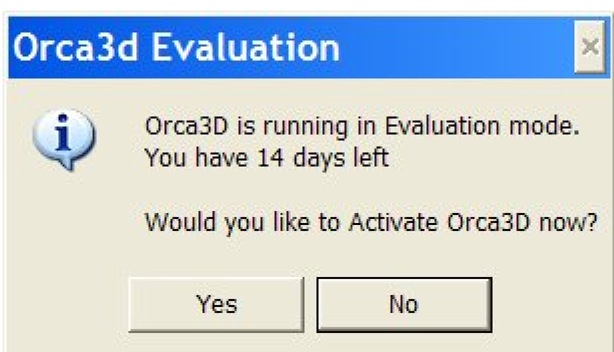
Step 2: Purchase the Software, Receive a License Code (sometimes called a License Number)

Step 3: Activate the Software

And, with a bit more detail:

Step 1: Download and Install the Software

You may download the software from our website: www.orca3d.com. You must install Rhino first. Next, run the Orca3D installation program, and follow the on-screen prompts. When you next run Rhino, you will see a message telling you that you are running Orca3D in "Evaluation mode." You may click "No" to begin using and evaluating Orca3D. Before your 15 day evaluation period is up, you should purchase a license (assuming of course, that the software meets your needs).



Step 2: Purchase the Software, Receive a License Code

You may purchase the software on the order page of our website: www.orca3d.com/

order/order.htm, or through a reseller. You will receive an 18-digit License Code. Do not lose this code.

Step 3: Activate the Software

Start Rhino, and in the Orca3D Evaluation message, click "Yes." The License Manager dialog will be shown:

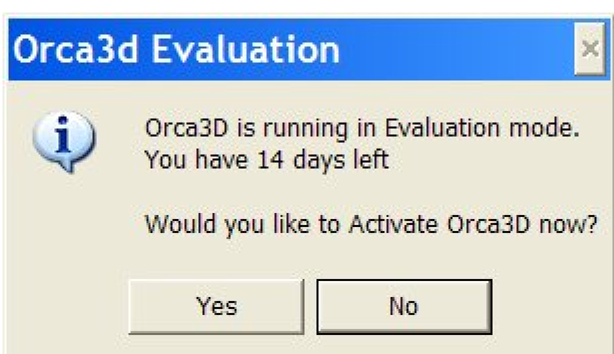
Select "Internet Activate," and then type or paste your License Code into the field at the bottom of the dialog. Click on "Activate." You will see the following message, and you are finished with the Licensing process. You are given the option to register your license, which makes it easier to help you with any license issues that you may have in the future.

12.2 Licensing Orca3D

After Orca3D has been installed, it will initially run in Evaluation mode, giving you 15 days to try the software before you decide to purchase. Each time Rhino is started, the Orca3D plug-in is loaded, and it checks for a valid license.

If a license is found, nothing is displayed and you will be ready to work in Rhino. Note that you can check the status of your Orca3D license by selecting *About* in the Orca3D menu.

If you are still in your 15-day evaluation period, you will see a screen showing the number of days remaining in the evaluation period, and asking if you want to continue the evaluation or activate the software.



To activate Orca3D, you must purchase a license, at which point you will receive a "**License Code"**(sometimes called a "**License Number**"). You can activate the software either by clicking on "Yes" in the dialog above, or by clicking on the Windows START button and navigating to the Orca3D folder, then clicking on the License Manager Utility. The License Manager Utility may also be started from the Orca menu, but note that any changes made to your license will not be effective until you close and re-start Rhino.

There are four methods that you may use to activate your license:

1. Automatic Activation via the Internet: 149 This is the easiest and most common method. Use this method when you are activating the software from the same computer on which the software is installed, the computer is connected to the Internet, and you don't have a proxy server or firewall that would prevent this from working.

2. Automatic Activation with a Proxy Server: 151 If you have a Proxy Server, you will use this method. You may require assistance from your IT department.

3. Manual Activation using the Internet: 152 If the computer on which Orca3D is installed is not connected to the Internet, or has a firewall that prevents the activation from being completed, you can log into a special website that will provide an unlocking code.

4. Manual Activation using Email/Phone: 156 This method is similar to the previous one, except that after you provide your information to us via phone or email, and we provide the unlocking code.

12.2.1 Automatic Activation via the Internet

To use Automatic Activation, you must be working on the computer where Orca3D is installed, and you must not have a Proxy Server. *You must have already installed Orca3D on this computer.*

You can start Automatic Activation either by clicking "Yes" on the Orca3D activation notice that appears at the startup of Rhino, or by clicking on the Windows START button and navigating to the Orca3D folder, then clicking on the License Manager Utility. The License Manager Utility may also be started from the Orca menu, but note that any changes made to your license will not be effective until you close and re-start Rhino.

Select the "Internet Activate" icon, and then enter your 18 digit **License Code** from the order email into the box provided. Click Activate.

After a moment, you should see the following screen:

You are given the option to register your license, which makes it easier to help you with any license issues that you may have in the future.

To check on the status of your Orca3D license, select *About* from the Orca3D menu in Rhino.

12.2.2 Automatic Activation with a Proxy Server

If you use a proxy server to access the Internet, you can set these parameters in the License Manager to allow you Activate. This process is identical to "Automatic Activation via the Internet 149," except that you must first enter your proxy server settings as described below.

To do this, click on the 'Help' menu on the toolbar and choose "Advanced" from the drop down menu (as below).

You will then need to enter your proxy server settings into the Dialog boxes provided. Click the "Use a proxy server.." check box and then complete the details in the two fields from your proxy server settings. You may need to contact your IT Dept. for these.

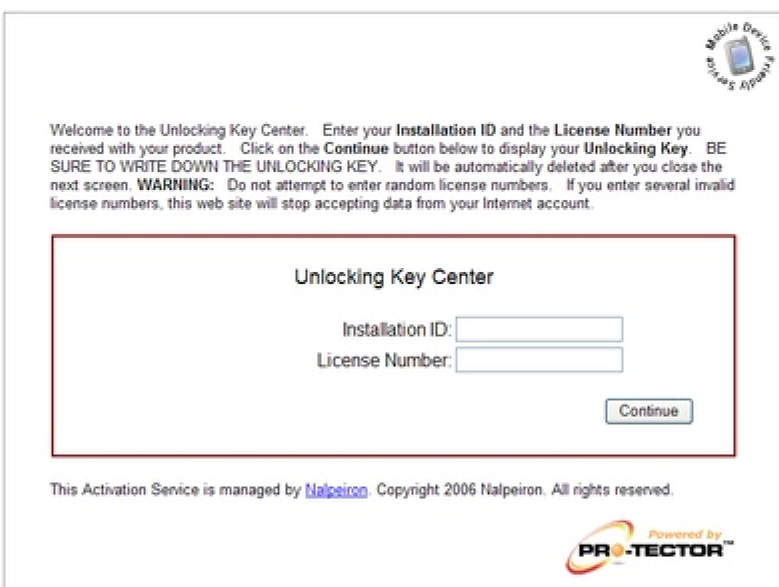
Then, continue with the Activation as you would in "Automatic Activation via the Internet 149."

12.2.3 Manual Activation using the Internet

Many users can't activate using the Automatic Activation process, as they have restricted access to the Internet due to a firewall, or they prefer not to license your PC this way. In order to assist these people we also provide a self-service website to gain "unlocking keys."

The steps for Manual Activation are as follows:

1. Visit http://www.unlockingcodes.com. Select the desired language, and the following screen will be shown (note that the "License Number" is the same as a "License Code"):

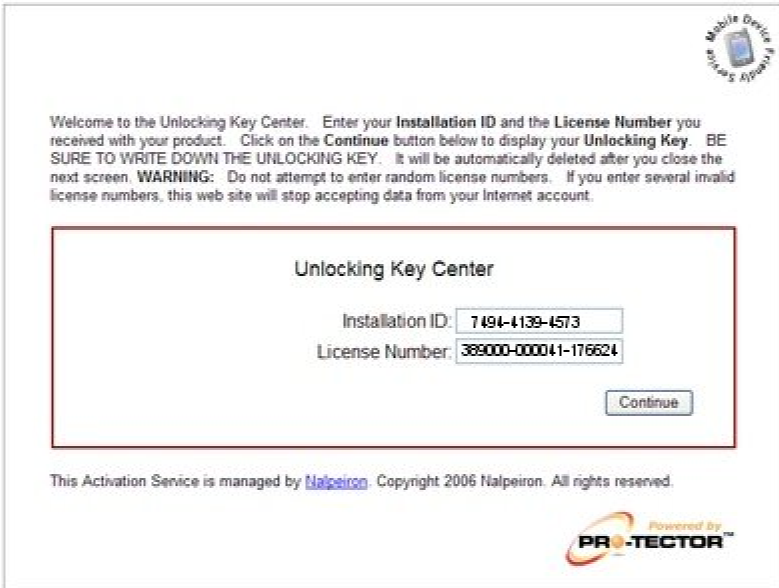


In order for you to license your program, an Installation ID and License Number will need to be provided by you as in the dialog box below. You will get the Installation ID by running the License Manager Utility.

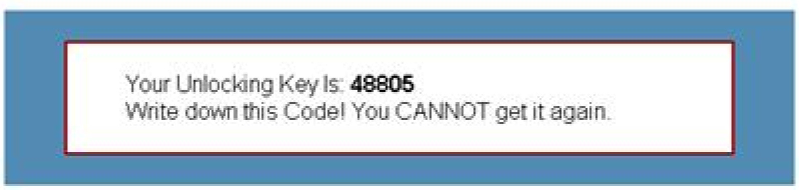
2. Start the License Manager utility by selecting "Activate" at startup, or by clicking on the Windows START button and navigating to the Orca3D folder, then clicking on the License Manager Utility. The License Manager Utility may also be started from the Orca menu, but note that any changes made to your license will not be effective until you close and re-start Rhino.

Select "Phone/Email License."

Your Installation ID will be displayed. Click on the Copy button next to the Installation ID, and paste it into the Installation ID field in the Unlocking Key Center web page. Type in the License Number that you were given when you purchased Orca3D.



Upon successful input of both Installation ID and License Number, click the **Continue** button to access the final screen.

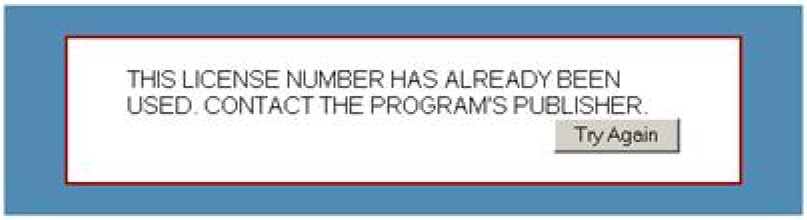


This shows the Unlocking Key for input into the dialog box back in the License Manager, below:

Enter the Unlocking Key in the Dialog Box and click the "Install License button. Upon successful entry of the unlocking key, you will be able to use Orca3D.

You may check the status of your Orca3D license at any time by selecting *About* from the Orca3D menu in Rhino.

Obviously, the Activation Service will check the use of License Numbers to prevent copying! If the license number has already been used, you will see the following screen:



12.2.4 Manual Activation using email/phone

If you prefer to activate over the phone or via email, please follow the steps described below. You will need to provide us with your License Code (given to you when you purchased your Orca3D license), and an Installation ID, which uniquely identifies the computer where you have installed the software.

1. Start the License Manager utility by selecting "Activate" at startup, or by clicking on the Windows START button and navigating to the Orca3D folder, then clicking on the License Manager Utility. The License Manager Utility may also be started from the Orca menu, but note that any changes made to your license will not be effective until you close and re-start Rhino.

Select "Phone/Email License."

Your Installation ID will be displayed. You can now call or email us with the following information:

- The License Code we sent with your order and;
- The Installation ID from the utility.

We will provide you with a simple 16 digit Unlocking Key; you just input this into the unlocking key field and then click “Install License”.

If you are getting the number by phone and typing it in by hand, you may separate the Unlocking Key into 4 groups of 4 digits each, separated by either a space or a – or just enter in the number as one long string of digits. Then click the Install License button. If you receive it by email, the easiest thing to do is to copy and paste it.

NOTE: You will be notified if you enter an invalid ***Unlocking Key*** and the Installation ID will immediately change afterwards.

Please note the change of “**STATUS**” showing the product as Licensed - A useful reference point. You may also check the status of your Orca3D license by selecting *About* from the Orca3D menu in Rhino.

12.3 Moving a License to Another Computer

The license for Orca3D may be moved from one computer to another, by either of two methods:

- Via a storage medium 158, such as a USB flash drive, floppy disk, LAN Server, external hard drive, etc.
- Via the internet 162, by temporarily returning your license to our license server, and then activating on the new computer.

Both methods are easy and reliable, but it's important to follow the steps closely.

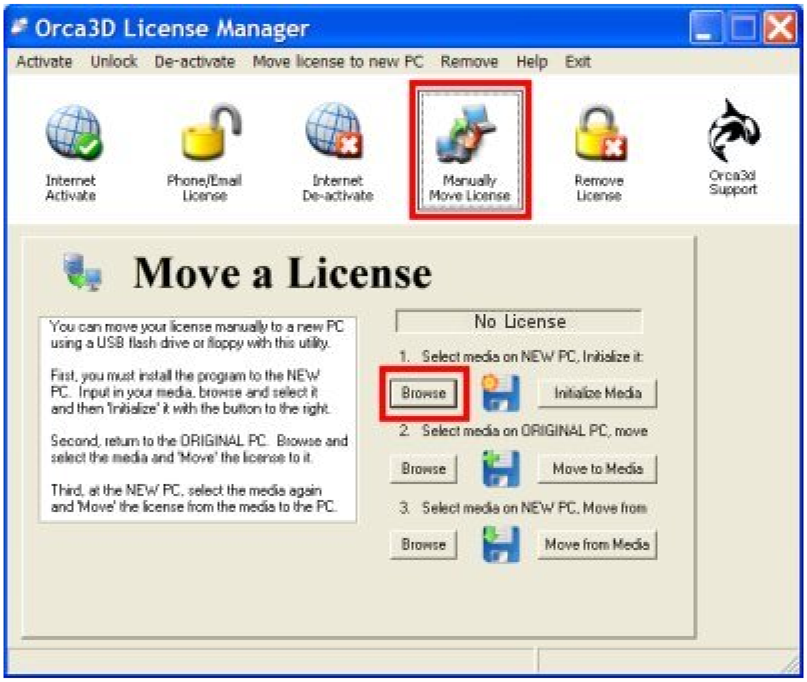
12.3.1 Moving a license using removeable media

If you are upgrading or wish to use the software on another PC you will need to move your license from the installed PC to a storage medium, which could be a USB flash drive, a floppy disk, a LAN Server, intranet mapped drives, portable hard drives or Zip type drives. Then you install Orca3D on the new PC and transfer the stored license to that PC. At that point the original PC will no longer be licensed.

It is important to follow these steps closely, in the order given below. Also, you MUST be running the same version of Orca3D on both computers. Otherwise, the transfer will fail and you will lose your license.

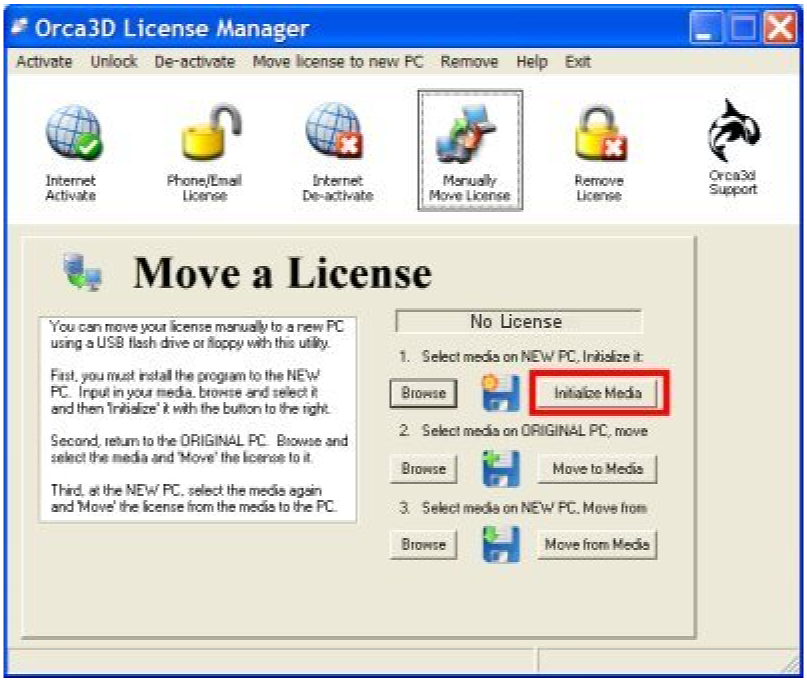
To manually move your license:

- Install Orca3D on your **new** PC; this will also install the License Manager Program
- Run License Manager on your **new** computer. The License Manager Utility may be started from the Orca3D menu in Rhino, or by clicking on the Windows START button, then selecting the License Manager from the Orca3D menu.
- Insert the drive media in the applicable drive and note the drive letter.



- Select the drive letter with your media in it by clicking the **Browse** button.

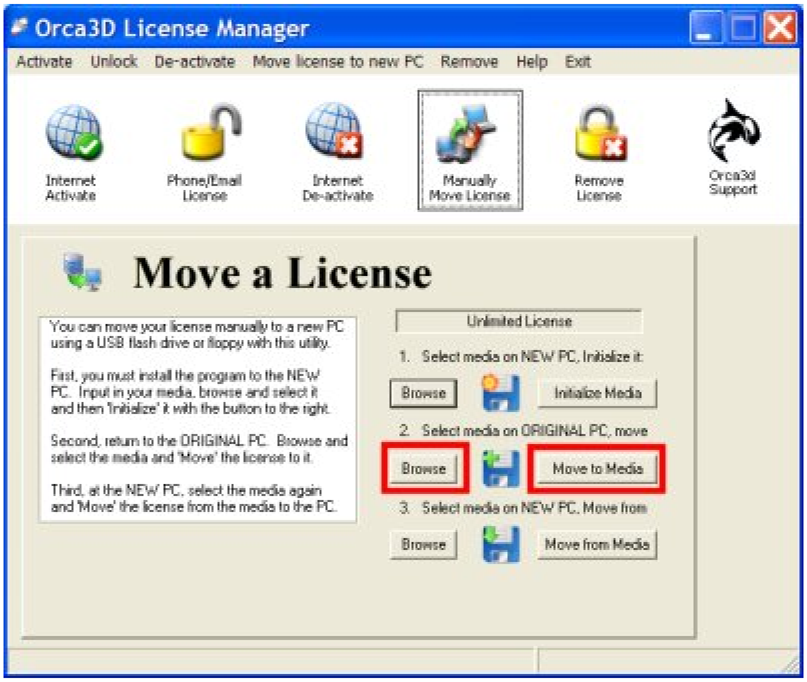
- The prompt box will display your PC drives. (as above)



- Click on **Initialize Media** for License Transfer to the media.

Then go back to the original PC:

- Run License Manager on the computer which already contains the license.
- If your media is removable (USB flash drive, etc.), install it on the original computer.
- Select the drive letter of your Initialized media by clicking the **Browse** button.
- Click on **Move To Media** button (as below)



Then go back to the new PC:

- Insert the media into the new computer and select the media drive by clicking the **Browse** button.
- Click on the **Move from Media** button.

You are finished. Orca3D is now licensed on your new computer. If the status does not read "Unlimited License," close the License Manager and re-start it to refresh the status.

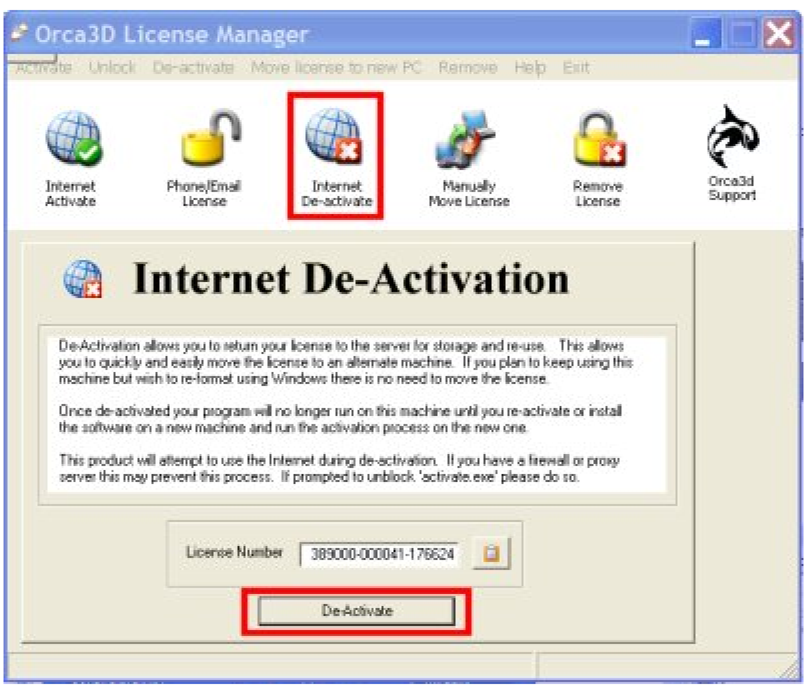
Another way to move your License 162 from PC to PC is to return it to the Web Activation Server and then activate it on the new computer later.

12.3.2 Moving a license using the Internet

Moving a license can be accomplished via the Internet, simply by returning the license from the original computer, and then installing Orca3D on the new computer and activating it. When you return the license, our license server records that fact, and will allow another activation to take place.

To access this function you will need to run the "**Internet De-Activate"** Utility in the License Manager. The License Manager Utility may be started from the Orca3D menu in Rhino, or by clicking on the Windows START button, then selecting the License Manager from the Orca3D menu.

Note: Do NOT use "Remove License," as this will permanently kill your license.



This function will allow you 'store' your license for future use or when you wish to move to another PC. You re-enter your License Number in the field and click the "De-Activate button. Once you have done this you can then re-use the same number in a new installation, using any of the Activation options. The PC which you have used this function on will now no longer be licensed.

When you have returned a license successfully you get the above screen.

Your "license number" will be saved locally and will appear in the license number box should you wish to re-activate on this PC.

If you now wish to move Orca3D to a new PC, just simply install it on the new computer and re-use the license number you have 'returned' to the server and go through the activation process again.

12.4 Removing a License

If for some reason it is necessary to remove your license from a computer and prove that you have done so, you can use the "**Remove License**" function in the License Manager. This will generate a "Proof of Removal Code" that we can use to verify that you have removed the license.

- Run the License Manager. The License Manager Utility may be started from the Orca3D menu in Rhino, or by clicking on the Windows START button, then selecting the License Manager from the Orca3D menu.
- Click on **Remove License** button
- When asked if you are sure, click Yes
- Contact us with the Installation ID (See green box above) that is displayed and the Proof of Removal Code (See red box above).
- We will confirm that your License has been successfully removed.

Part XIII

13 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.

13.1 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	600.000	m^3	600	m^3	0.000
VCB	-2.000	m	-2.000	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	60.000	m^2	60.0	m^2	0.000
Wetted Surface	340.000	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 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 is 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

13.2 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:		512,950.0	kg	
	Analytic		**Orca3D**		**% Error**
Draft	5.000	m	5.000	m	0.000
Displaced Volume	500.000	m^3	500.0	m^3	0.000
VCB	-2.500	m	-2.500	m	0.000
Area Moment of Inertia	833.330	m^4	833.3	m^4	0.004
Waterplane Area	100.000	m^2	100.00	m^2	0.000
Immersed Area	50.000	m^2	50.0	m^2	0.000
Wetted Surface	300.000	m^2	300.00	m^2	0.000
Wetted Girth	20.000	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:		410,360.0	kg	
	Analytic		**Orca3D**		**% Error**
Draft	4.000	m	4.000	m	0.000
Displaced Volume	400.000	m^3	400.0	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 3.1.2 Cube Free Float Results Weight II

Water Density: 1025.9 kg/m^3	Input weight:		615,540.0	kg	
	Analytic		**Orca3D**		**% Error**
Draft	6.000	m	6.000	m	0.000
Displaced Volume	600.000	m^3	600.0	m^3	0.000
VCB	-2.000	m	-2.000	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	60.000	m^2	60.0	m^2	0.000
Wetted Surface	340.000	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	125.67	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:		206,269.4	kg	
	Analytic		**Orca3D**		**% Error**
Draft	4.000	m	4.007	m	0.175
Displaced Volume	201.062	m^3	201.1	m^3	0.019
VCB	-2.000	m	-1.997	m	0.150
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	32.000	m^2	32.0	m^2	0.000
Wetted Surface	150.796	m^2	150.84	m^2	0.029
Wetted Girth	16.000	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:		154,702.1	kg	
	Analytic		**Orca3D**		**% Error**
Draft	3.000	m	3.005	m	0.167
Displaced Volume	150.796	m^3	150.8	m^3	0.002
VCB	-2.500	m	-2.498	m	0.080
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	125.66	m^	125.67	m^	0.005

Surface	4	2		2	
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:		257,83 6.8	kg	
	Analyt ic		**Orca3 D**		**% Error**
Draft	5.000	m	5.008	m	0.160
Displaced Volume	251.32 7	m^ 3	251.3	m^ 3	0.011
VCB	-1.500	m	-1.496	m	0.267
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	40.000	m^ 2	40.1	m^ 2	0.250
Wetted Surface	175.92 9	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	
	Analytic		**Orca3D**		**% Error**
Draft	5.000	m	5.003	m	0.060
Displaced Volume	32.725	m^3	32.7	m^3	0.076
VCB	-1.250	m	-1.248	m	0.160
Area Moment of Inertia	30.680	m^4	30.6	m^4	0.260
Waterplane Area	19.635	m^2	19.62	m^2	0.076
Immersed Area	12.500	m^2	12.5	m^2	0.000
Wetted Surface	43.905	m^2	43.92	m^2	0.034
Wetted Girth	11.180	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	
	Analytic		**Orca3D**		**% 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	28.099	m^	28.11	m^	0.038

Surface		2		2	
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	
	Analytic		**Orca3D**		**% Error**
Draft	6.000	m	6.003	m	0.050
Displaced Volume	56.549	m^3	56.5	m^3	0.086
VCB	-0.500	m	-0.498	m	0.400
Area Moment of Inertia	63.617	m^4	63.5	m^4	0.184
Waterplane Area	28.274	m^2	28.26	m^2	0.051
Immersed Area	18.000	m^2	18.0	m^2	0.000
Wetted Surface	63.223	m^2	63.25	m^2	0.042
Wetted Girth	13.416	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	150.849	m^4	150.5	m^4	0.232

Longitudinal Area Moment of Inertia	471.405	m^4	471.0	m^4	0.086
Waterplane Area	56.569	m^2	56.53	m^2	0.068
Immersed Area	8.250	m^2	8.3	m^2	0.604
Wetted Surface	90.358	m^2	90.37	m^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:		205,427.5	kg	
	Analytic		**Orca3D**		**% Error**
Draft	4.000	m	4.005	m	0.125
Displaced Volume	200.241	m^3	200.2	m^3	0.021
VCB	-0.753	m	-0.75	m	0.443
Transverse Area Moment of Inertia	150.849	m^4	150.0	m^4	0.563
Longitudinal Area Moment of Inertia	471.405	m^4	470.5	m^4	0.192
Waterplane Area	56.569	m^2	56.47	m^2	0.174
Immersed Area	20.024	m^2	20.1	m^2	0.379
Wetted Surface	154.686	m^2	154.77	m^2	0.054
Wetted Girth	11.464	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

13.3 Mesh Density Accuracies

4 Mesh Density Accuracies

The following plots show the reduction in percent error for the verified parameters as the Orca3D mesh density is increased. The cube is not included in the plots since the accuracy is not affected by lower mesh densities.

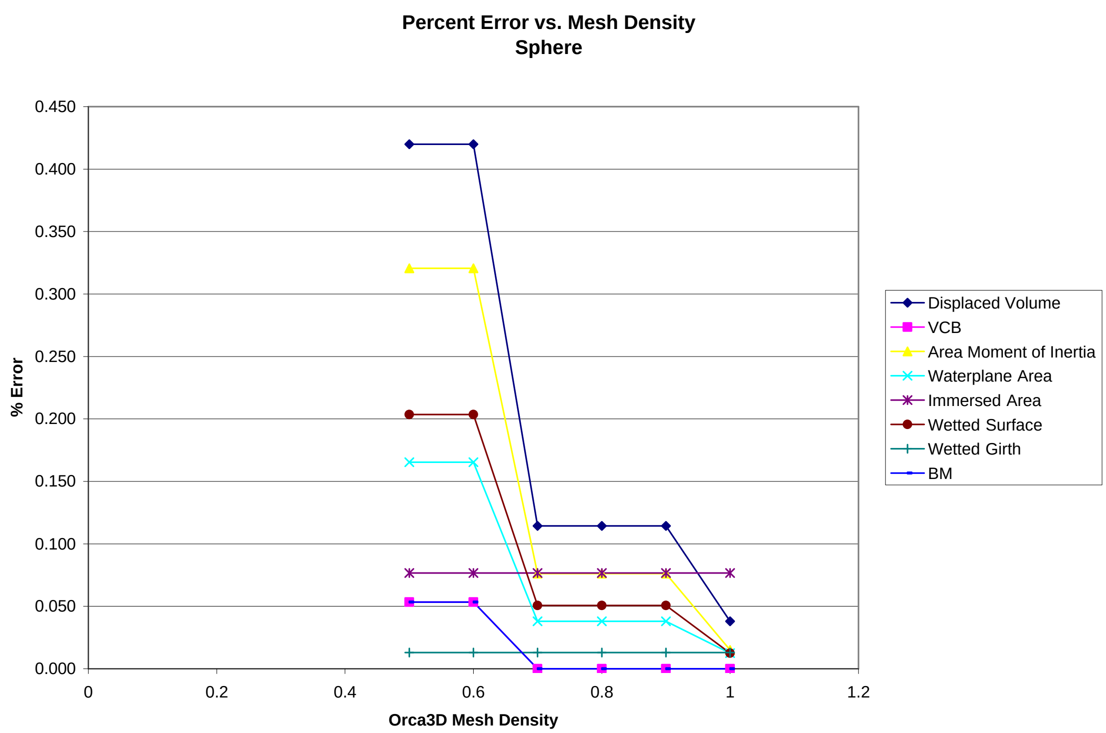


Figure 4.1 Sphere Mesh Density Accuracy

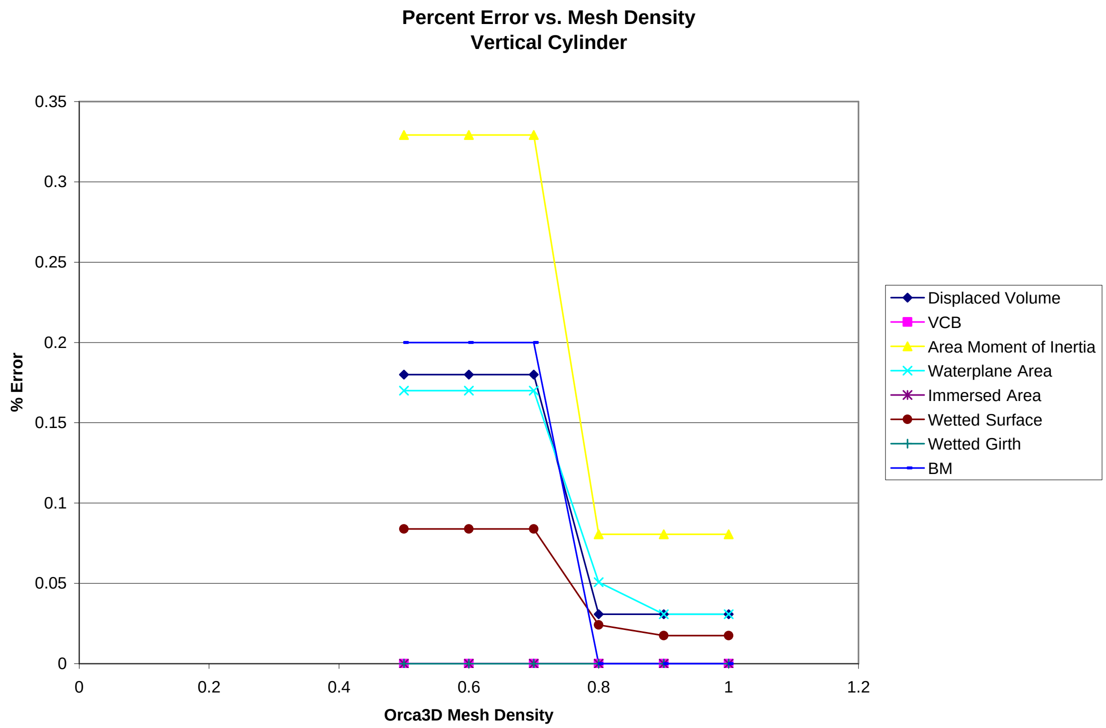


Figure 4.2 Vertical Cylinder Mesh Density Accuracy

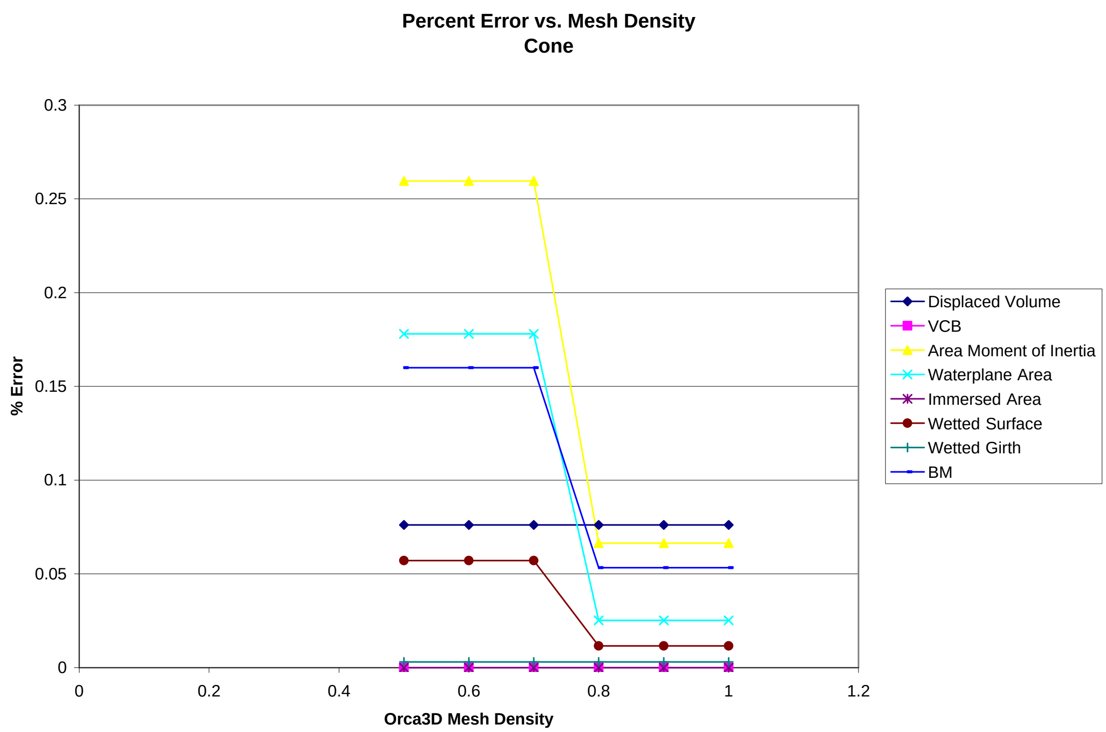


Figure 4.3 Cone Mesh Density Accuracy

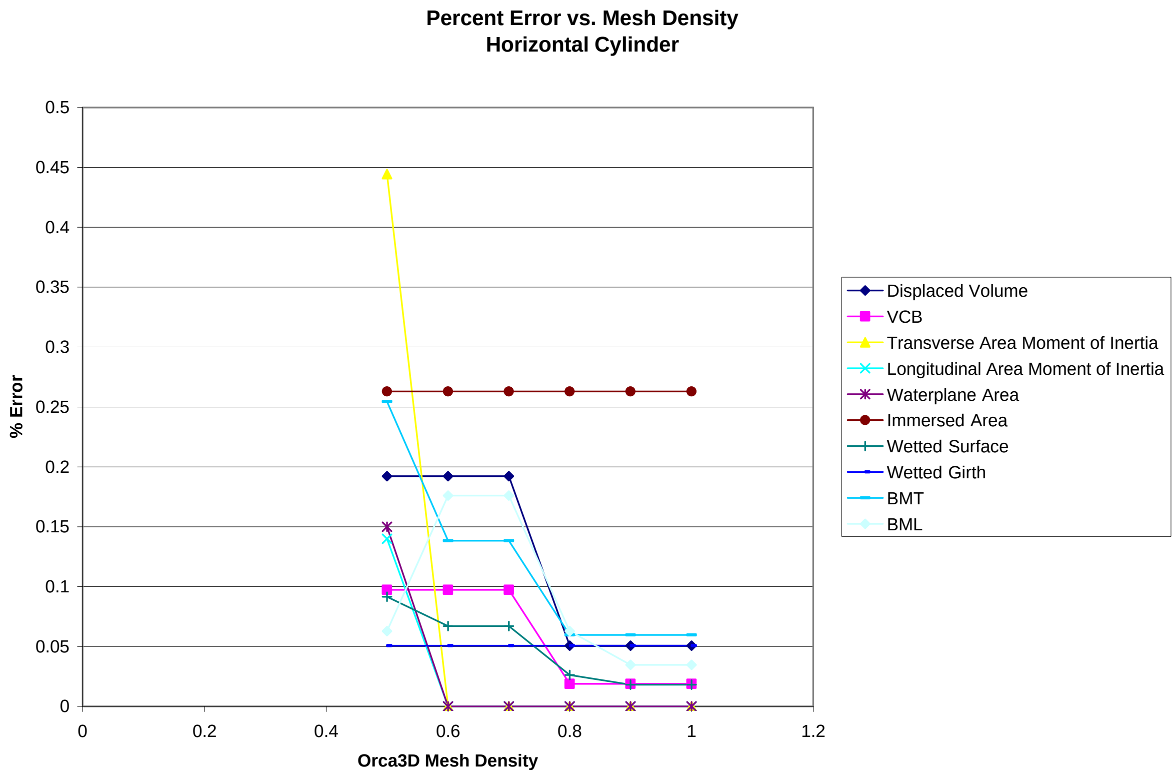


Figure 4.4 Horizontal Cylinder Density Accuracy

13.4 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.

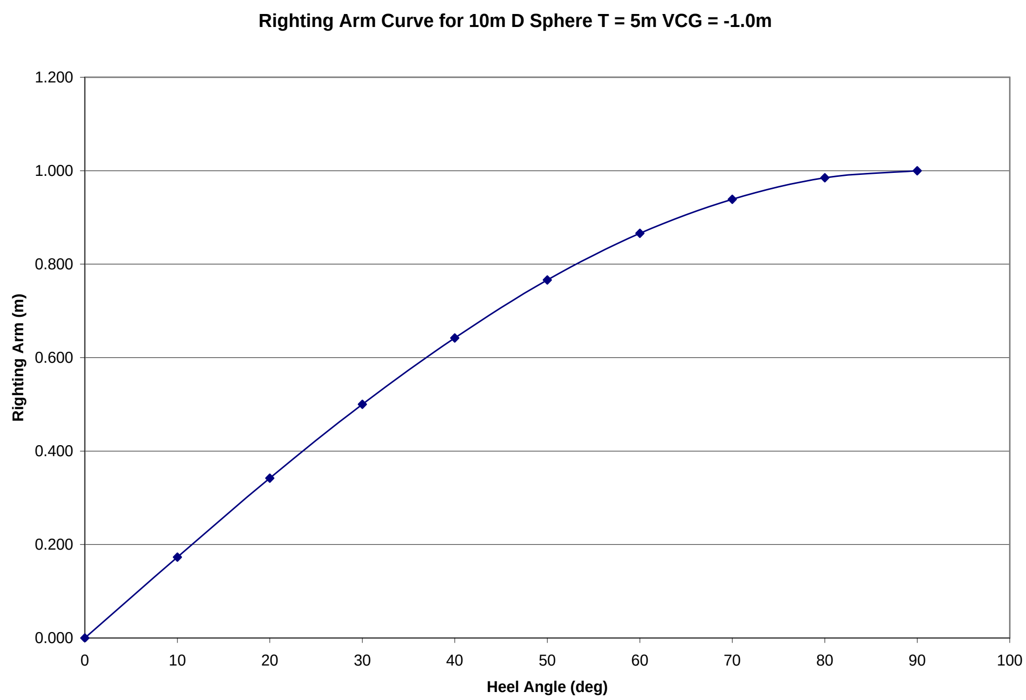


Figure 5.1 Righting Arm Curve for 10m D Sphere VCG = -1.0m

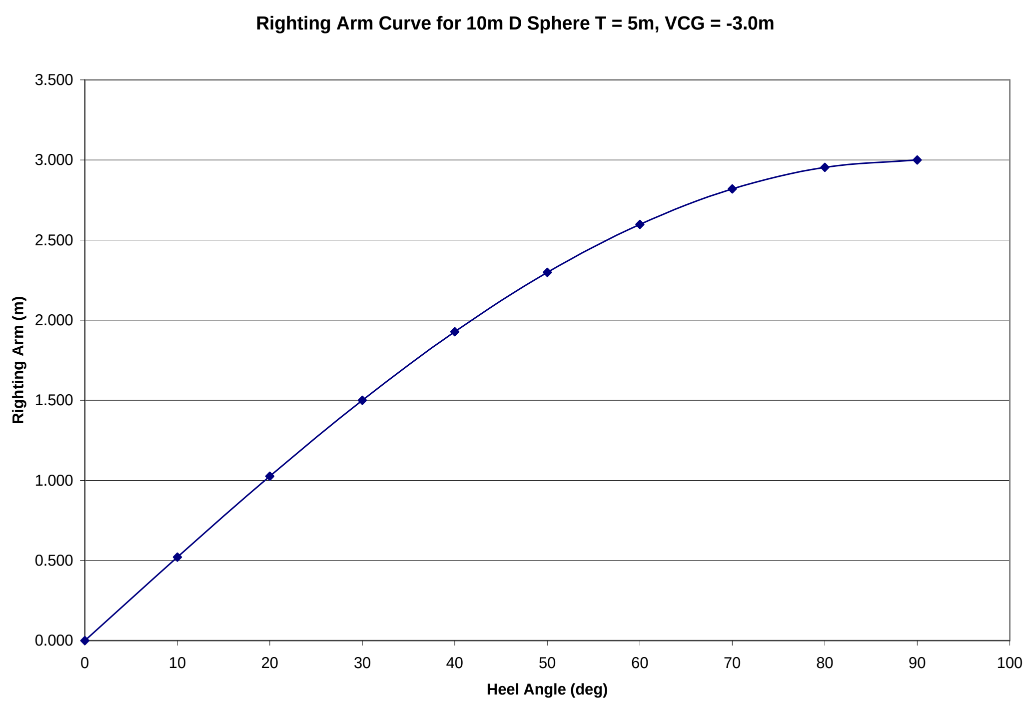


Figure 5.2 Righting Arm Curve for 10m D Sphere VCG = -3.0m

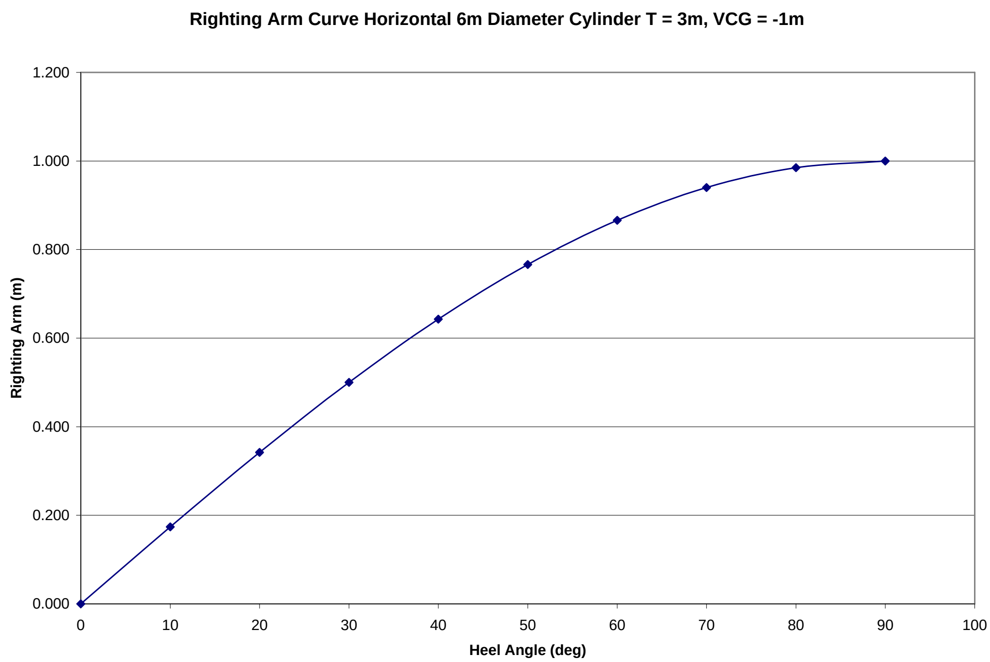


Figure 5.3 Righting Arm Curve for 6m D Horizontal Cylinder VCG = -1.0m

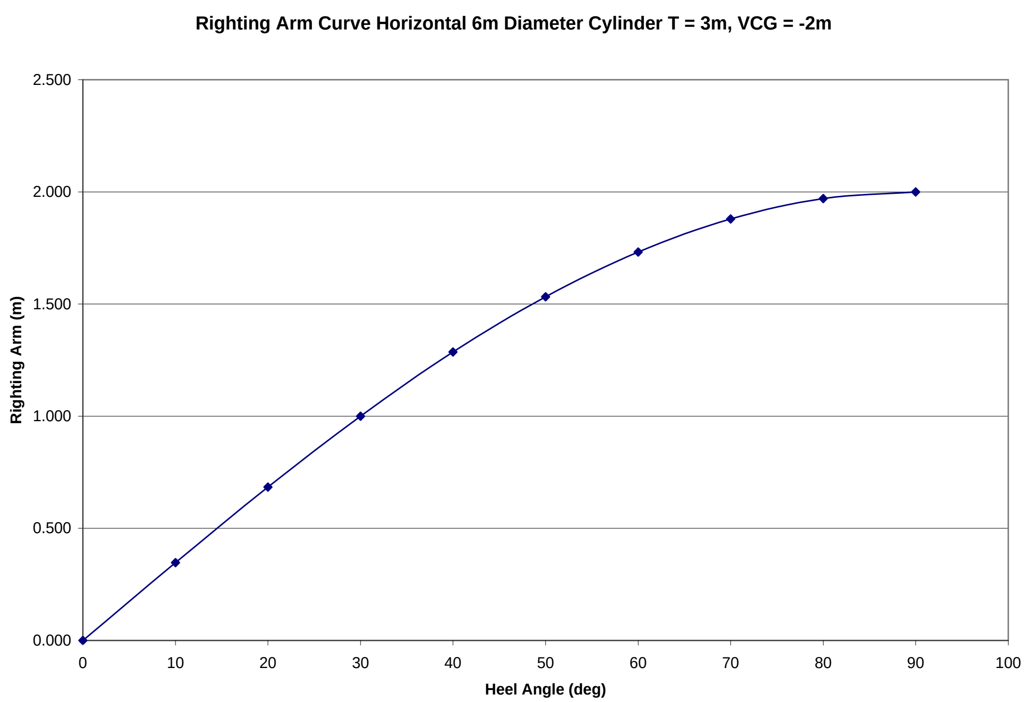


Figure 5.4 Righting Arm Curve for 6m D Horizontal Cylinder VCG = -2.0m

Part XIV

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OrcaShowSection: This command is used to hide or show the Orca3D sections.

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