Geometric Modeling of the Hull Form

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Ship Design I

MSc in Marine Engineering and Naval Architecture

Summary

Introduction

Beginning: CAM Systems

- The need to prepare geometrical models of the ship hull began in the 1950s with the introduction of the numerically control in the plate cutting equipment of the shipyards
- The requirements of accuracy associated with the manufacturing process demands mathematical bases capable of complying with the specific shape characteristics of the ship's hull
- With the increasing power of the computers came the evolutions from 2D to 3D domain, from curves representations to surface representations

From CAM to CAD

- With the continuous increase in capacity and availability of the personal computers the interactive systems became more appealing
- The human interfaces also have improved both in the hardware (mouse, digitizers, track balls, gloves) and in the software aspects (windows, menus, dialog boxes, icons)
- The hull modeling systems have started to be used not only for manufacturing but also in the early stages of ship design
- First system were only concerned with the description of the hull for the purpose of basic naval architecture computations
- The next step was the concept design of the hull shape

Classification of Methods by Objective

- Development of a new hull
  - Application in the basic design of the ship
  - Global restrictions (displacement, form coefficients, LCB, etc.)
  - More freedom for the design of local shape
- Representation of an existing hull
  - Application in ship repair
  - Necessary to respect a set of local restrictions
  - Supply information to the workshops for the cut and forming of plates and stiffeners

Classification of Methods by Input Data

- Set of <u>cross sections and the contours FWD/AFT</u>
  - Offset data from a systematic hull series
  - Offset table of an existing ship (no drawings available)
- Set of <u>main lines</u>
  - Lines that control globally a set of coefficients and variables related with different aspects of the ship (Midship section. Section at the FWD PP, FOB, FOS, LWL, DKL, SAC, etc.)
  - Lines obtained from Lines Plan drawings or from surface models
  - Lines defined parametrically

Mathematical Representations of the Hull Form

Hull Form Representation Methods (1)

Author	Institution/ Country	Year	Objective	Data	Method.	Function
D. Taylor	US Navy	1915	Creation and systematic variation	Hull Parameters	Function of draught	Polinom.
Weiblum	Univ. Berlin	1934	Systematic variation	Hull Parameters		Polinom.
Benson	UK	1940	Creation of Lines	Hull Parameters		Polinom.
Lackenby	BSRA UK	1950	Systematic variation	Parent Hull	Affine Transform.	
Thieme	Univ. Hamburg	1952	Creation of Lines	Hull Parameters		Polinom.
Taggart	US	1955	Creation of Lines	Hull Parameters		Polinom.

Hull Form Representation Methods (2)

Author	Institution / Country	Year	Objective	Data	Method.	Function
Theilheimer & Starkwheather	US Navy	1957	Interpolation and Fairing	Offsets	Function of draught	Discont. cubics
Rosing & Berghuis	Holland	1959	Fairing	Offsets	Function of draught	
Rosing & Berghuis	Holland	1959	Fairing	Offsets	Function of draught	
Pien	US Navy	1960	Approxim.	Offsets	Sections Method	Polinom.
Kerwin	MIT US	1960	Rough Approxim.	Offsets	Sections Method	Polinom. Legendre
Martin	NPL UK	1961	Rough Approxim.	Offsets of the Area Curve		Polinom. Chebysh.

Hull Form Representation Methods (3)

Author	Institution/ Country	Year	Objective	Data	Method.	Function
Lidbro	Sweden	1961	Interpolation	Offsets	Surface Fitting	
	Bergen Norway	1961	Fairing	Offsets	Function of draught	Polynomials
F. Taylor	UK	1962	Interpolation	Waterline offsets		Chebyshev Polynomials
Miller & Kuo	Univ. Glasgow	1963	Interpolation	Offsets	Function of draught	Polynomials
Berger & Webster	Todd Shipyard US	1963 1966	Fairing	Offsets	Surface Fitting	Discont. Cubics
Williams	SSET Sweden	1964	Creation of Lines	Hull Parameters	Function of draught	Polynomials

Hull Form Representation Methods (4)

Author	Institution/ Country	Year	Objective	Data	Method.	Function
Hamilton & Weiss	MIT US	1964	Creation of Lines	Hull Parameters	Surface Fitting	Surface cubic
Bakker	NSMB Holland	1965	Fairing	Offsets	Sections Method	
Gospodnetie	NRC Canada	1965	Interpolation	Offsets	Sections Method	Integrals Elliptical
Corin	US Navy	1966	Fairing	Offsets	Sections Method	Discont. Cubics
Tuck & V. Kerkzek	US Navy	1968	Fairing	Offsets	Sections Method	Conform. mapping
Söding	Germany	1966	Creation of Lines	Offsets	Sections Method	Discont. polynom.
Kantorowitz	DSRI Denmark	1967	Interpolation	Offsets	Surface Fitting	Orthog. polygon.

Hull Form Representation Methods (5)

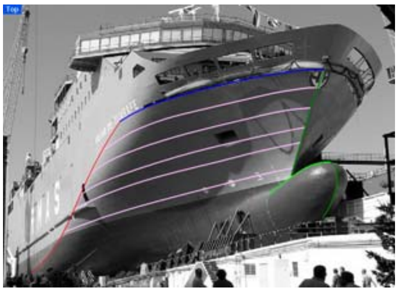
Author	Institution/ Country	Year	Objective	Data	Method.	Function
Kaiser et al.	Germany	1968	Interpolation	Offsets	Surface Fitting	Surface polynom.
Kaiser et al.	Germany	1968	Interpolation	Offsets	Surface Fitting	Surface and polynom.
AUTOKON	Norway		Fairing	Offsets	Sections Method	Spline polynom.
Hoshino, Kimura, Igarashi	Mitsubishi Japan	1966	Fairing	Offsets	Sections Method	Discont. Cubics
Breitung	TU Berlin Germany	1969	Fairing	Offsets	Method Surfaces	Discont. Cubics
Kwik	Univ. Hamburg Germany	1969	Creation of Lines	Hull Parameters	Sections Method	Polynom.

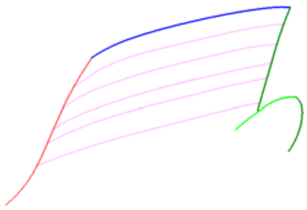
Hull Form Representation Methods (6)

Author	Institution/ Country	Year	Objective	Data	Method.	Function
Buczkowski	Poland	1969	Fairing and Creation of Lines	Offsets, parameters	Method Surfaces	
VIKING	Sweden		Interpolation	Offsets	Surface Fitting	Splines and conics
Kuiper	NSMB Holland	1970	Creation of Lines	Hull Parameters	Function of draught	Polynom.

Methodology for the Geometric Modeling of the Hull Form

Learn from Existing Hulls



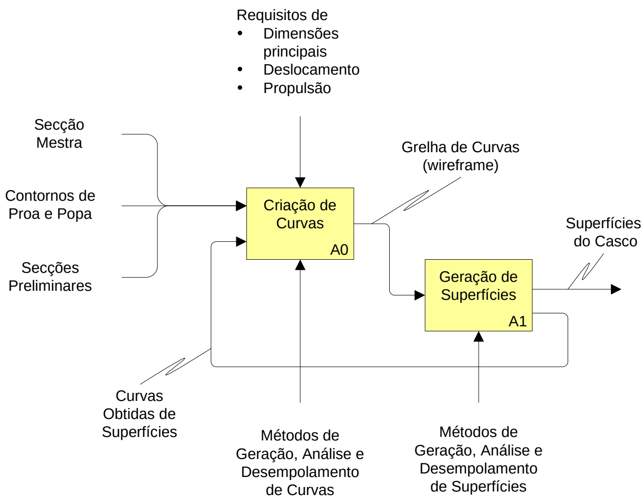


- The visual analysis of existing hulls (drawings, photos, ..) allows a better understanding of the design of the shape: the form of main curves, the existence of flat regions and knuckles, the types of transition between surfaces, etc.
- Plate seams, edges, apparent contours, reflection lines, etc. can be used to help visualize the shape

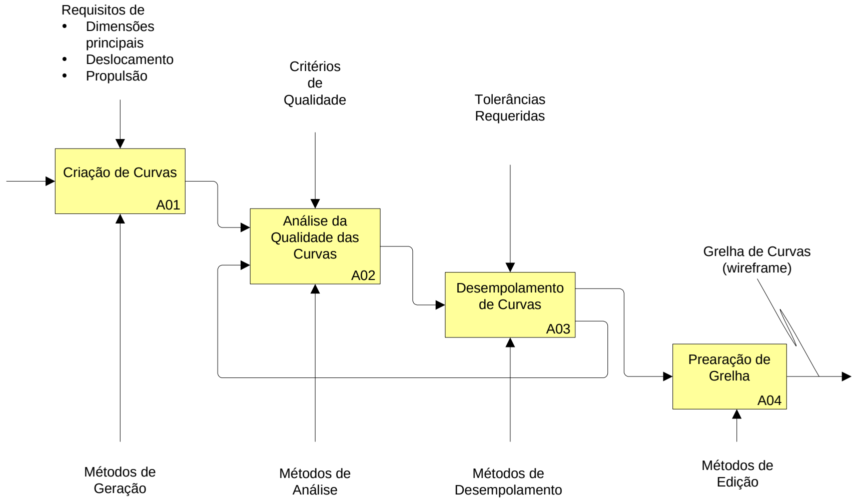
Hull Modeling Steps

1. Create a wireframe with the available data (main curves, sections, etc.)
2. Analyze the hull shape and plan its decomposition in surface patches
3. Edit the wireframe curves (split, join, etc.) in order to support the surface generation – try to obtain 4 edge curves for the generation of each patch
4. Try to define first (or at least sketch) the surfaces (FOS, FOB, etc.) that may eventually define boundary conditions (position, tangency, curvature) to others
5. Define the surface patches using boundary conditions to take into consideration the continuity across patches
6. Analyze (Gauss curvature, reflection lines) the resulting surfaces
7. If the quality is not enough, improve the fairing of the relevant edge and inner curves, go back to step (5) and repeat the surface generation

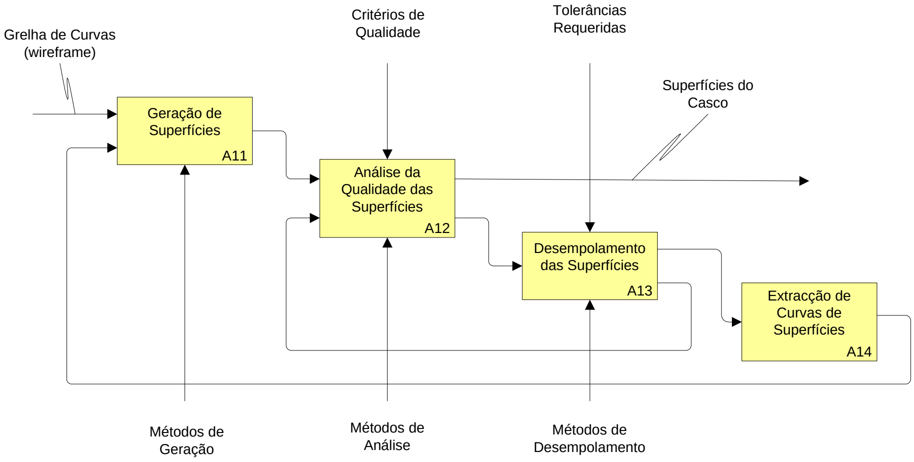
Hull Geometric Modeling



Curves Model (Wireframe)

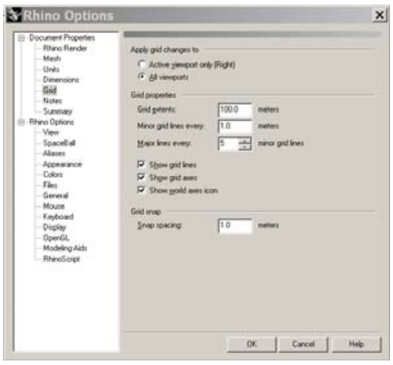


Surface Model



Methodology for Hull Modeling

- Define units
- Define auxiliary grid

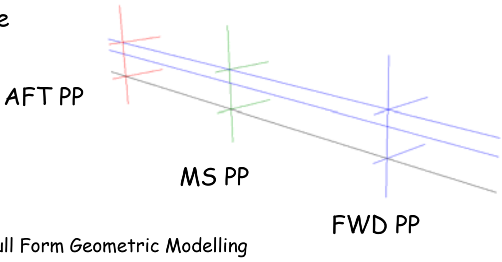


Guidelines for Work Sequence (1)

- **Create LAYERS** to organize the entities, for example:
  - Reference Lines
  - Polylines
  - Curves
  - Surfaces
  - FWD Contour
  - AFT Contour
  - Sheer Line
  - Camber Lines
  - Cross sections
  - Waterlines
  - Longitudinal sections
  - Diagonals

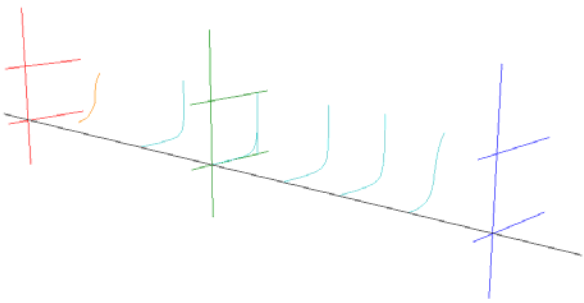
Guidelines for Work Sequence (2)

- **Create the reference lines**, in the respective layers:
  - Longitudinal base line
  - Perpendiculars AFT, FWD and MS
  - Transverse base lines AFT, FWD and MS
  - Longitudinal deck line (horizontal)
  - Transverse deck lines AFT, FWD and MS
  - Design draught line



Guidelines for Work Sequence (3)

- Create midship section
- If the hull has a parallel middle body, locate copies of the midship section on the limits AFT and FWD
- Create 2/3 sections AFT and FWD



Guidelines for Work Sequence (4)

- Create a bow contour curve
- Create the cross section of the bulb at FWD PP

Guidelines for Work Sequence (5)

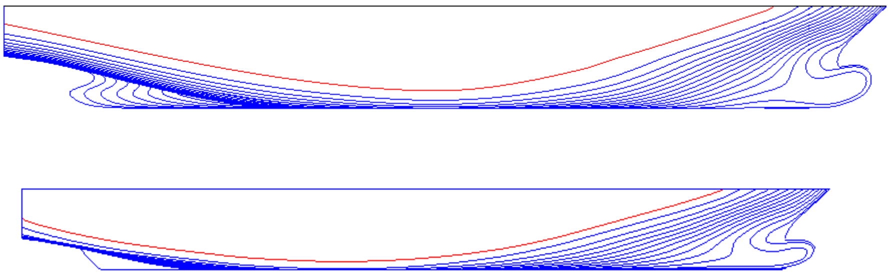
- Draw the axis line of the propeller shaft
- Create the stern contour

Guidelines for Work Sequence (6)

- Draw the FOB curve
- This curve must take into consideration the extent of the parallel middle body and the stern and stem contours

Guidelines for Work Sequence (7)

- Draw the FOS curve
- This curve must take into consideration the extent of the parallel middle body



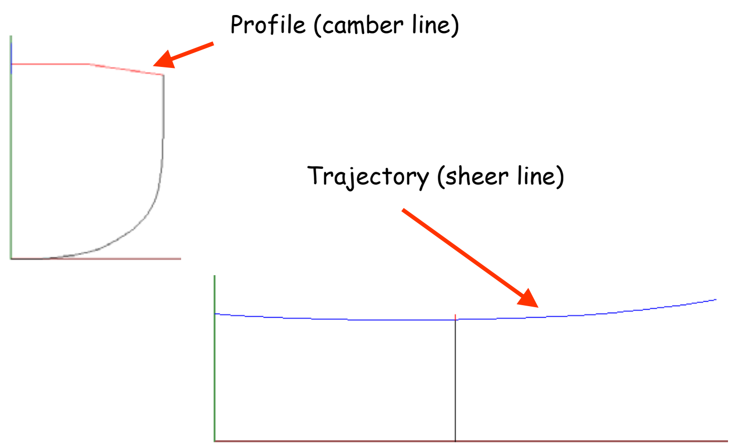
RoPax Ship

Guidelines for Work Sequence (8)

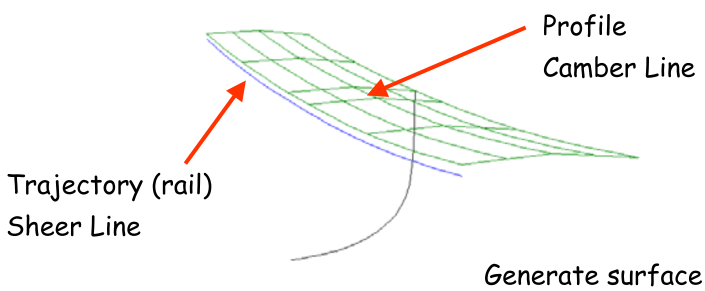
- Generate the shell surface(s)
- Generate the bulb surface(s)
- Create the sheer line
- Create the camber line(s)
- Generate the deck surface

Modeling of Some Specific Ship Shapes

Deck Surface Generation (1)

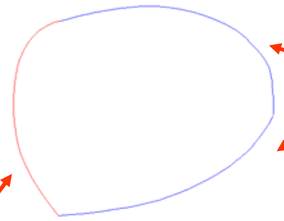


Deck Surface Generation (2)



Generate surface with
Surface/Sweep 1-rail

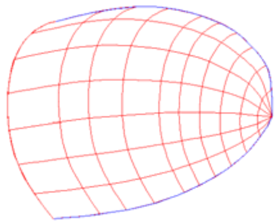
Bulb Modeling

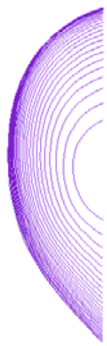


Trajectory curves (rails)

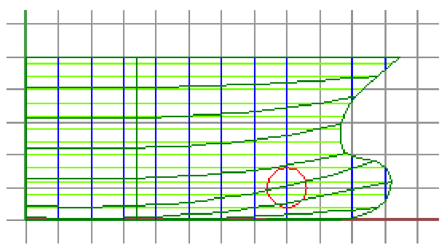
Profile

Sweep 2 rails



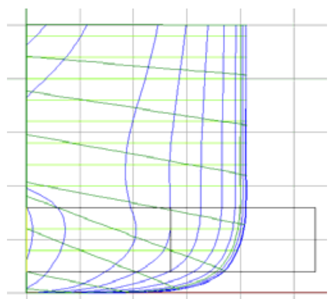


Thruster Tunnel Modeling (1)



Create a circle on the centerline plane:

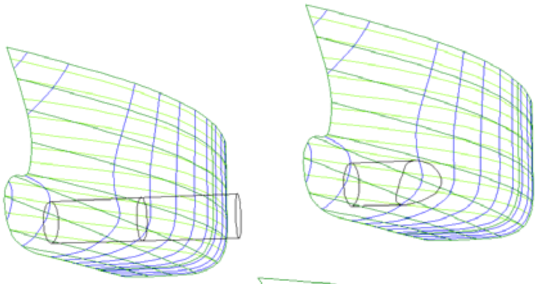
Curve/Circle/Center,Radius



Generate cylinder:

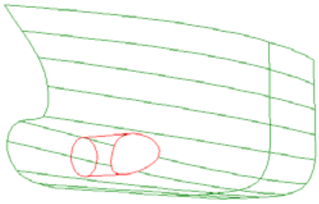
Surface/Extrude curve/Straight

Thruster Tunnel Modeling (2)



Trim cylinder by the shell:

Edit/Trim



Create opening on the shell:

Edit/Trim

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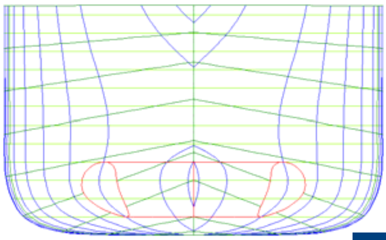
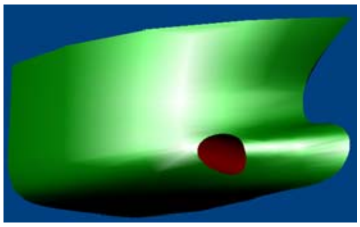
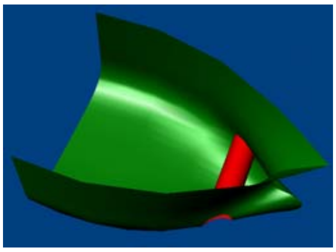
Thruster Tunnel Modeling (3)







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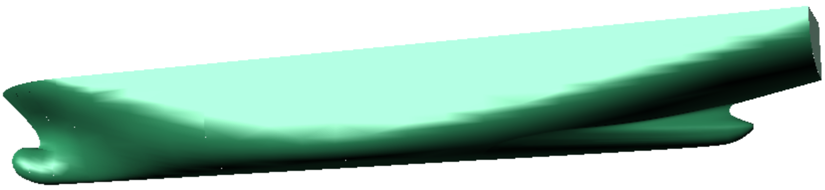
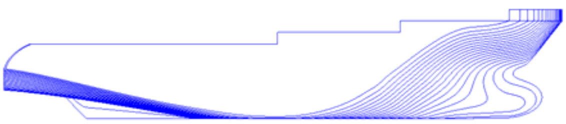
Examples

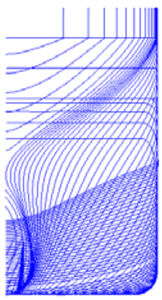
Container Carrier



RoPax Vessel

Supply Vessel





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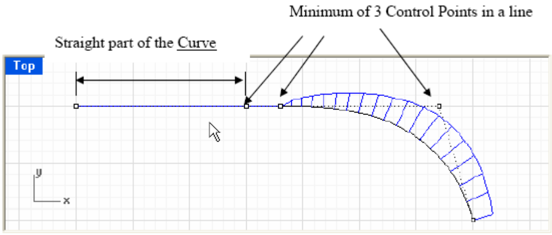
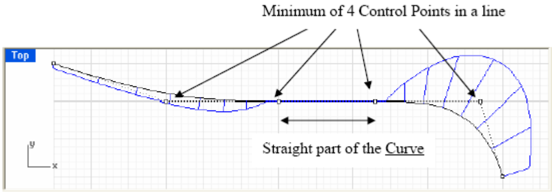
- Wang, Hu and Zou, Zao-Jian (2008), "Geometry Modeling of Ship Hull Based on Non-Uniform B-spline", Journal of Shanghai Jiaotong University (Science), Vol.13, No.2, April, pp.189-192.
- ✓ Wen, A.; Shamsuddin, S. and Samian, Y. (2005), "Ship Hull Fitting Using NURBS", Proceedings of the Computer Graphics, Imaging and Vision: New Trends (CGIV'05).

Annex A. Curve Modeling Techniques

Straight Lines and Fillets

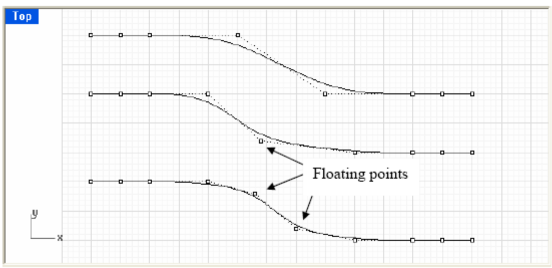
A NURBS curve represents a straight line when it has <n> collinear control points (n = order)





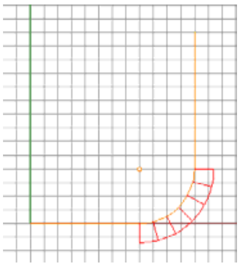
Transition between the straight line and the tangent curve - 4 collinear points

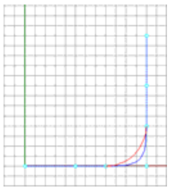
Transition between Two Straight Lines



- Without additional points
- With 1 additional point
- With 2 additional point

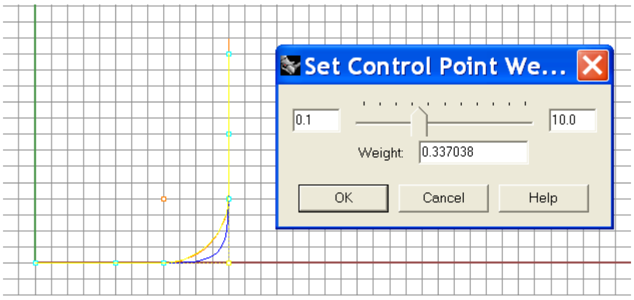
Circular Arcs





- Draw arc
- Create a single curve and edit the weight of the control point on the vertex of the bilge until the required arc is obtained

- <Join> lines with arc – the resulting curve is NOT continuous

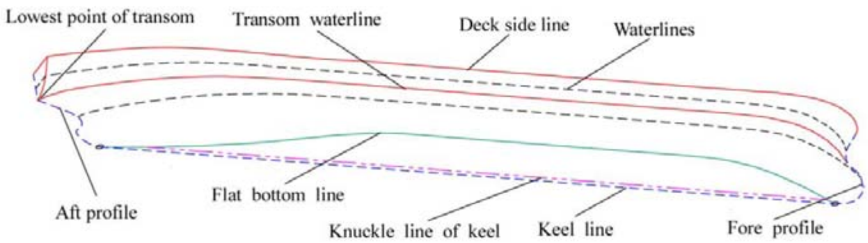


Annex B. Single Surface Modeling

Hull Modeling by a Single Surface (1)

Li et al (2007a; 2007b) propose the following methodology

1. Interpolate all waterlines and deck side line(s) applying the existing hull form data to create the initial section curves
2. If there are knuckles in the aft/fore profile (see Fig. 1), interpolate the aft/fore profiles



Hull Modeling by a Single Surface (2)

3. Interpolate body lines
4. Interpolate the waterline through the lowest point of transom (see Fig. 1, "transom waterline") if there are no data corresponding to it in the offset, then insert this waterline into the section curves sequence, otherwise jump this step and step (3) to step (5)
5. Insert the section curve used for construct bottom ("keel line and knuckle line of keel", in Fig. 1) into the section curves sequence
6. Unify knot vectors and degrees of all the section curves created above and obtain the NURBS definition data, i.e. the control points, knot vector and weights, with unified knot vectors, denoted as U
7. Interpolate the curves in V direction and obtain the NURBS definition data of the hull surface
8. Construct hull surface

Annex C. Guide for Lab Classes

Task 1. From Curves to Surfaces

Task 1. From Curves to Surfaces (1)

- Generate the hull offsets from the Series 60, using HullS60, and for example the following main dimensions:

  Lpp = 130.0

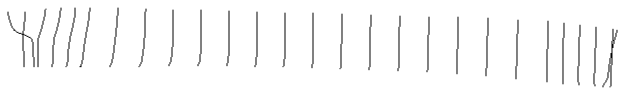
  B = 22.0

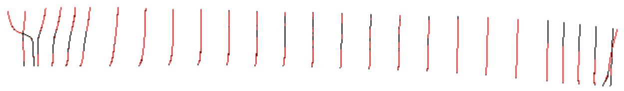
  T = 8.2

  DisplV = 0

  Cb = 0.78
- Import the resulting cross sections and contours AV/AR in DXF format into Rhino3D
- Create layers: Curves, Surfs, BaseLine, FOB, FOS, DeckEdge, Planes
- Set layer <Curves> active and fit curves to the imported polylines
- Move into the <Front> view, hide the <DXFImport> layer, and <Trim> the first and last sections by the respective stern and bow contours
- Set layer <BaseLine> active and draw a single line between the first points of the stern and of the bow contours

Task 1. From Curves to Surfaces (2)

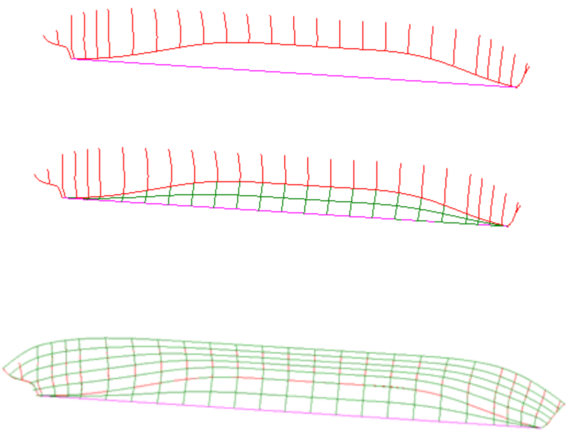


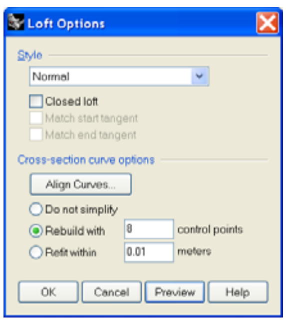


Task 1. From Curves to Surfaces (3)

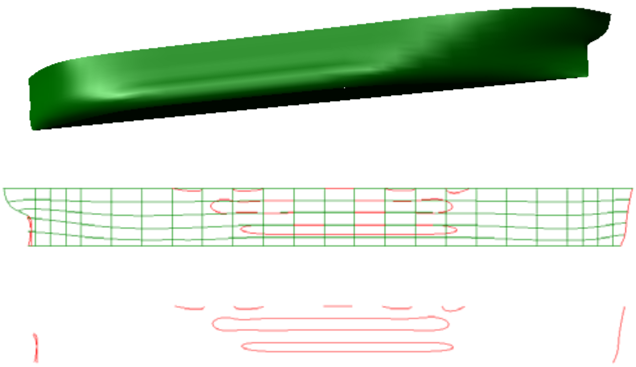
- Set layer <FOB> active and draw a curve joining the points of each section that lie on the base plane
- Set layer <Surfs> active and generate the bottom surface by <Edge Curves> using the base line curve and the FOB as edges
- Generate a single hull surface by <loft> curves from the stern contour to the bow contour
- Determine the FOS curve
  - Intersect the surface with the tangent plane
  - To guarantee a complete intersection curve move the plane inwards by a small distance (Example: 0.05 m)
  - Fair the resulting curve
  - Project the curve back into the correctly positioned tangent plane
- Set layer <DeckEdge> active and draw a curve joining the upper of each cross section and contour

Task 1. From Curves to Surfaces (4)



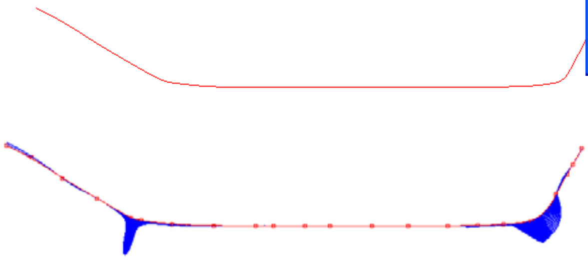


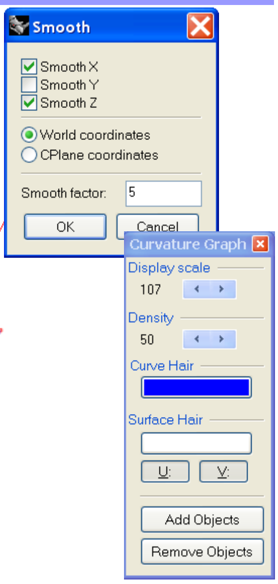
Task 1. From Curves to Surfaces (5)



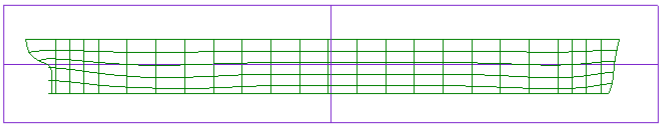
Task 1. From Curves to Surfaces (6)

- Curve can be faired interactively by deleting and moving points
- <Transform/Smooth> function can also be used, but is not very efficient

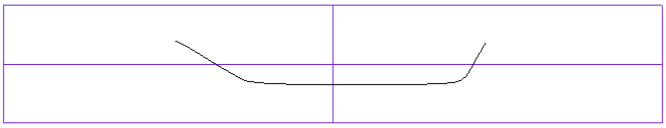




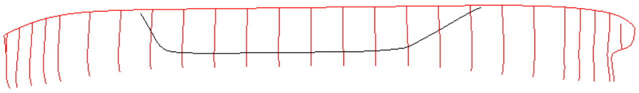
Task 1. From Curves to Surfaces (6)



Surface/Plane/
3 Points

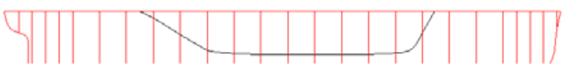


Curve/Curve
From Objects/
Project



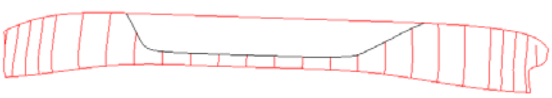
Curve/Free-form/
Interpolate Points

Task 1. From Curves to Surfaces (7)

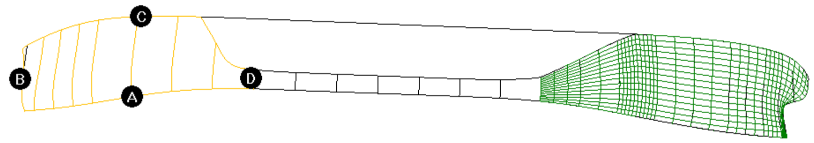


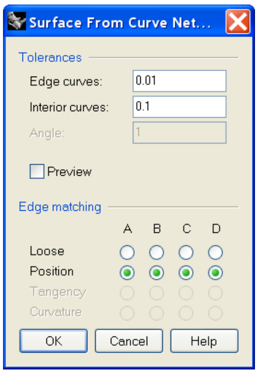
View / Set CPlane /
To Object

Curve/Extend Curve/
Extend Curve



Task 1. From Curves to Surfaces (8)





Task 2. Modeling Specific Areas

Task 2. Modeling Specific Areas

- Deck surface
  - Sheer line
  - Camber line
  - Planar/curved surfaces
  - Determine the deck line at side (DAS)
- Bulb surface
  - Cross section in the FWD PP
  - Bow contour
  - Waterline at bulb height
- Bow tip
- Stern panel

Task 3. From Surfaces to Curves

Task 3. From Surfaces to Curves

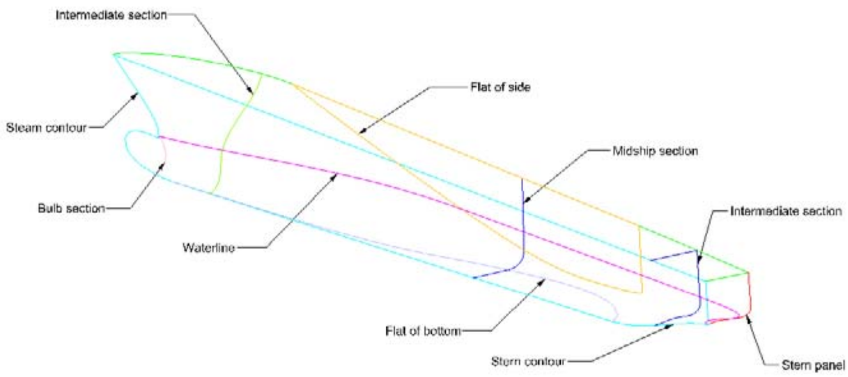
- Extract the main lines from an existing surface model
  - Center plane longitudinal contour
  - FOB
  - FOS
  - Midship section
  - Additional sections FWD/AFT and at the FWD PP
  - LWL
  - DAS
- Lines fairing

Task 4. From Main Curves to Surfaces

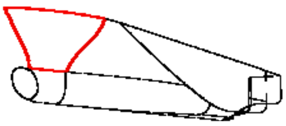
Task 4. From Main Curves to Surfaces

- Generation of the hull surface from the main lines
- Introduce knuckle lines by projection of curves into the surfaces
- Split and rebuild surfaces affected by knuckles

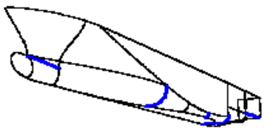
Main Lines for Hull Modeling



Processing the Curves

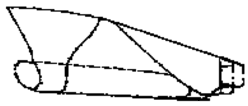


Split curves in order to define four boundaries for each surface



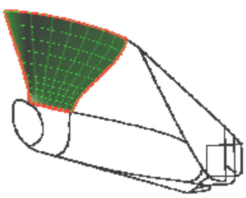
If necessary, create auxiliary curves to define the four boundaries

Control points before refit curves



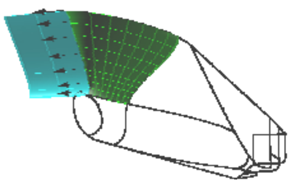
Control points after refit curves

Generating the Surfaces (1)

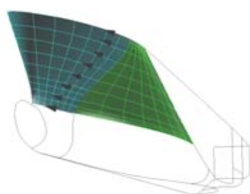


Use the four boundaries to build each surface

(‹surface by curve network› in Rhinoceros 3D)

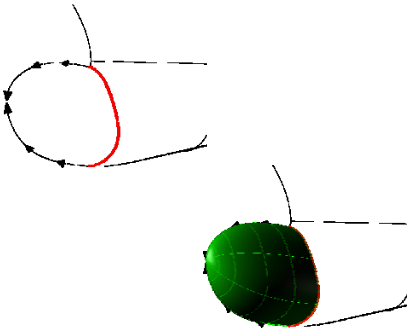


Generate auxiliary surfaces to control known tangents at the boundaries

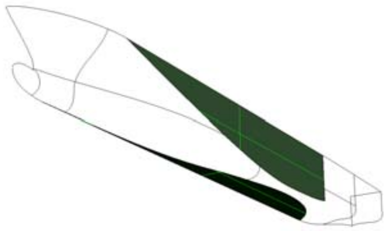


Use the previous surface to define the boundary continuity of the next adjacent one

Generating the Surfaces (2)

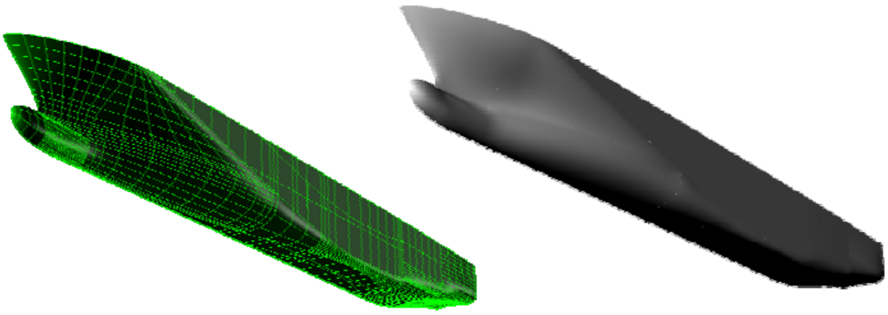


Sweep the bulb section trough two rails to create the surface



Use planar surfaces whenever possible. Simplify… Simplify… Simplify!

Generating the Surfaces (3)



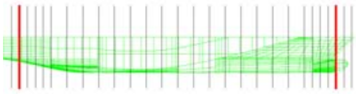
After some hours of hard work…

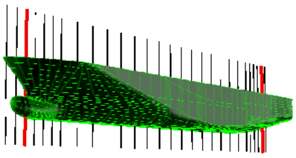
Class 5. From the Model to the Drawing

Class 5. From the Model to the Drawing

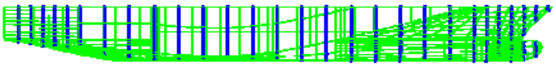
- Extract from the surface model of the half-hull the curves for the traditional Lines Plan drawing:
  - Cross sections
  - Longitudinal sections
  - Waterlines
  - Diagonals
- Export for other CAD systems
  - DXF format
  - IGES format

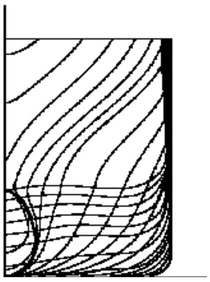
Getting the Lines Plan - Sections





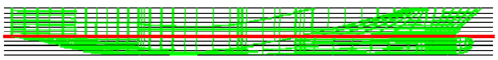
Define the location of each section. Make sure you create one at the after and another at the forward perpendiculars

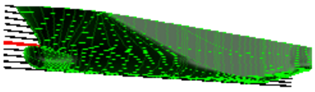




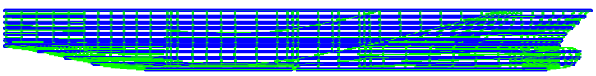
Project the lines into the hull surfaces. Note that the projection direction must be perpendicular to the profile view plane.

Getting the Lines Plan - Waterlines

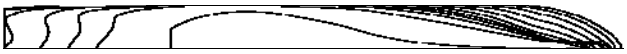




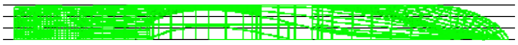
Define the location of each waterline. Make sure you create one at the design draft

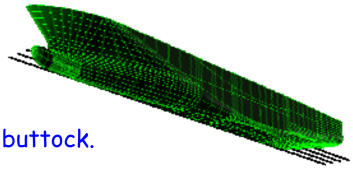


Project the lines into the hull surfaces. Note that the projection direction must be perpendicular to the profile view plane.

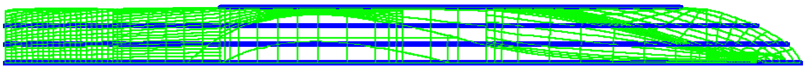


Getting the Lines Plan - Buttocks

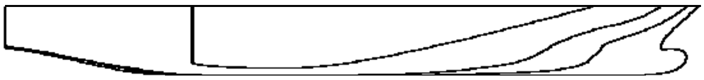




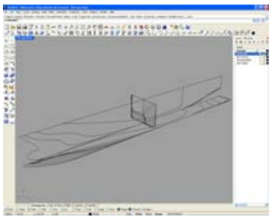
Define the location of each buttock.



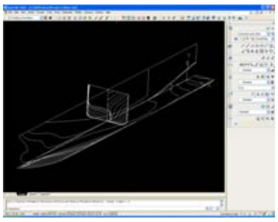
Project the lines into the hull surfaces. Note that the projection direction must be perpendicular to the top view plane.



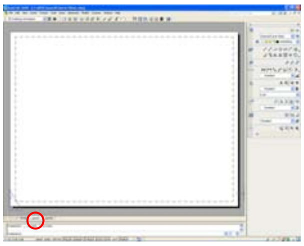
Drawings in AutoCad



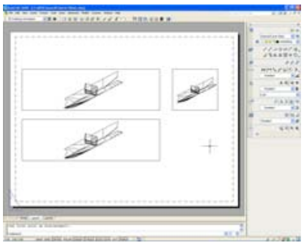
Export lines to AutoCAD (.dxf, .dwg)



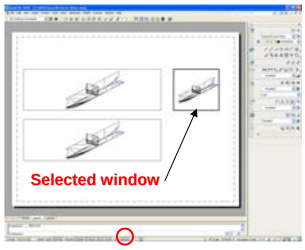
Creating the Drawing in AutoCad (1)



Select layout view

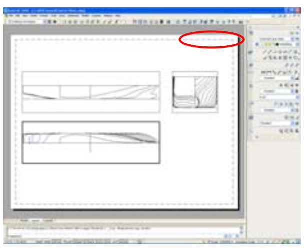


Create the three views to the model in the layout using *mview* command

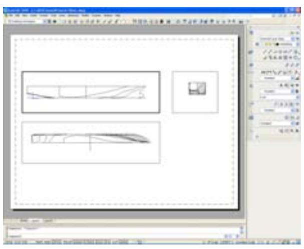


Change to model space in layout view and select each window

Creating the Drawing in AutoCad (2)

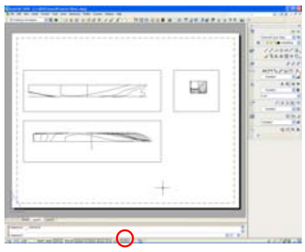


Set the appropriate view for each selected window



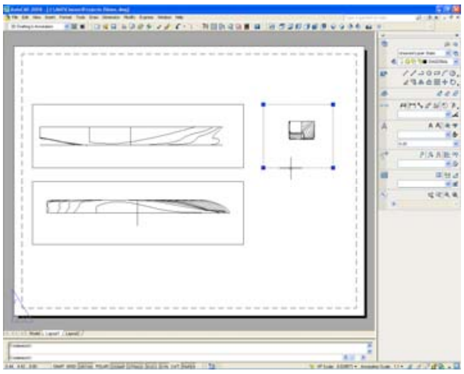
Set the same scale for each window:

Zoom->Scale->1/200xp



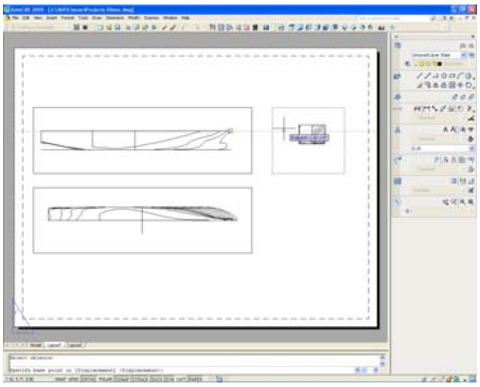
Change back to paper space view

Aligning the Views in AutoCad (1)



Select the view you want to align

Aligning the Views in AutoCad (2)



Move the view window to the correct position:

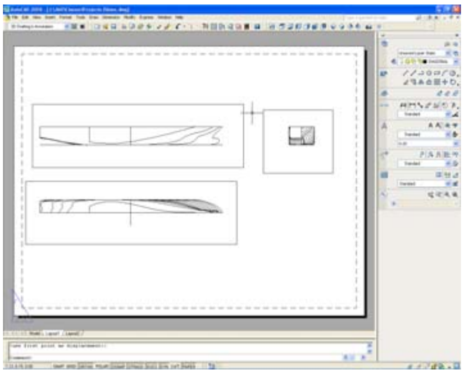
. Select move

. The origin point is a point on the deck in the section view

. The destination point must be aligned with a point on the deck in the profile view

. Use *OTrack* option to align destination point with the point on the deck

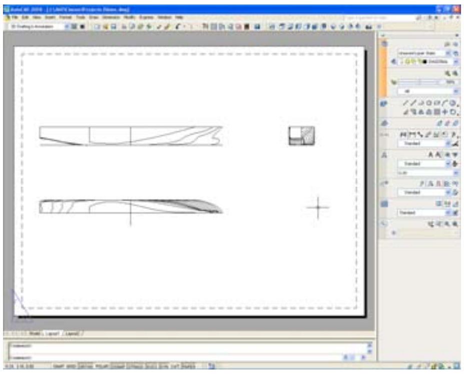
Aligning the Views in AutoCad (3)



Do the same procedure for the waterline view.

Now the lines in the views are aligned and the view windows are not. Although is not necessary you can align the views by aligning their corner points in the paper space. This will have no effect on the position of lithe lines.

Aligning the Views in AutoCad (4)



Create a new layer called "MViews", select the three views and change them to that layer. Then hide the layer "MViews" and the borders of the windows will be hided.

Then, don't forget to complete the lines plan…

Annex D. Geometric Modeling Systems used in Naval Architecture

Manuel Ventura

Rhinoceros 3D (1)

- www.rhino3d.com (Last version: v4.0 Sp.6)
- Generic system (NOT designed specifically for naval architecture)
- Geometric entities used:
  - Polylines
  - Curves NURBS
  - PolyCurves
  - Surfaces NURBS
  - Grid
  - PolyGrid

Rhinoceros 3D (2)

- Surface creation methods:
  - Extrusion
  - Lofting
  - Sweeping 1 rail / 2 rails
  - Revolution
  - Interpolation of 2, 3 or 4 edge curves
  - Interpolation of regular grid of curves

Rhinoceros 3D (3)

- Methods of Curve and Surface analysis:
  - Normal curvature
  - Gauss curvature
  - Reflection lines

- Import/Export
  - Large variety of formats supported
  - IGES
  - DWG/DXF

FastShip (1)

- www.proteusengineering.com (Last version: ????)
- System designed specifically for naval architecture
- Entities
  - NURBS surfaces
- Library of hull forms
- Computation of hydrostatics (output in HTML, Excel, txt)
- Hull transformations
- Generates Offset Table in ASCII text file

Information based in available version (V6.1.25)

FastShip (2)

- Import/Export
  - IGES
  - IDF
  - 3dm (Rhino3D)
- Generation of new hull forms for the Library

AutoShip v8.0

- www.autoship.com (Last version: v9.0)
- System designed specifically for naval architecture
- Entities
  - Curves B-Spline
  - Surfaces B-Spline
- Import/Export
  - IGES translators very inefficient
- Computes hydrostatics at the design waterline

MaxSurf (1)

- www.formsys.com/maxsurf (Última versão: v12.0)
- System designed specifically for naval architecture
- Information based in version v11.03
- Entities:
  - Markers (polylines)
  - Surfaces
- Surfaces are created directly from grids of control points (25 x 25 max.)
- Allows the generation of contour tables (Sections, Waterlines, Top Lines, Diagonals) in pre-defined locations.

MaxSurf (2)

- Parametric transformations to change:
  - Parallel middle body
  - Midship section coefficient
  - Flare
- Files with extension <.mdf> (Maxsurf Design File)
- Import and export NURBS surfaces in IGES format
- Imported surfaces do not have limits of dimensions
- Import/Export works well with Rhino3D
- Computes hydrostatic characteristics at the design waterline

MaxSurf / PreFit (3)

- Creates single surface from a file of cross sections and contours, represented by polylines, designated by <Markers>
- Method of approximation of curves based in genetic algorithms
- The file format is the following:
  - Bow contour
  - Transverse sections
  - Stern contour

	Station	Longitudinal	Offset	Height
Bow				
Sections				
Stern				

Ficheiro de <Markers> para PreFit

The format of data in the text file is the following:

- Values in columns with:
  - station number
  - X (station position)
  - Y (offset from centre)
  - Z (height)
- Each line must end with Carriage Return <CR> and the columns must be separated with <TAB> characters
- Each section must have the first point over the centerline plane and the last over the sheer line

MultiSurf v5.0.2

- www.aerohydro.com
- System designed specifically for naval architecture
- Relational Geometry
- Curves in surfaces
- Surface curvatures
  - Normal
  - Gauss
  - Mean
- Export
  - DXF
  - IGES (works quite well with Rhino3D)

BEAN – The Virtual Shipyard

- www.thevirtualshipyard.com
- System designed specifically for naval architecture
- Includes the following functionalities:
  - Geometric modeling of surfaces
  - Naval Architecture computations
  - Photogrametry

DELFTship

- www.delftship.net
- Last version: v3.2 (Nov. 2007)
- Modeling based on subdivision surfaces
- Includes libraries with foil shapes:
  - NACA
  - UIUC (University of Illinois at Urbana-Champaign) (www.ae.uiuc.edu/m-selig/ads.html)
- Applies hull form transformations (Lackenby)
- Computes power prediction
  - Sailing vessels

Pilot3D v1.222 (1)

- www.pilot3d.com
- Geometric entities:
  - Points
  - Lines
  - Polylines
  - Curves NURBS
  - Surfaces NURBS
- Import
  - DXF
  - IGES

Pilot3D v1.222 (2)

- Functionalities
  - Surface flattening
  - Surface reconstruction

Ship Hull Characteristics Program (SHCP)

- Program from the USA Navy for stability and longitudinal resistance computations (Last version PC-SHCP v5.0)
- Gave origin to a file format for the description of the hull form that has become a standard for data transfer used by many other software systems for naval architecture (GHS, AutoHydro, etc.)
- SHCP file format
  - All the dimensions in Imperial units (1ft = 0.3048 m)
  - Axis of abscissas with origin at FWD PP, and oriented AFT
  - Definition of the sections:
    - NoPoints, Xsec
    - y, z
    - y, z

Orkinus

- www.orkinus.com
- Surface optimization (with CFD)
- Lofting documentation:
  - Lines fairing (SeaSolution software)
  - Shell plating
  - Structures modeling
  - Profile sketches
  - Nesting
  - Hydrostatics computation (SeaHydro)
- Presentation modeling

ShipConstructor

- www.shipconstructor.com
- System for ship structures, piping and duct systems modeling integrated in AutoCAD (plugin)
- External MS SQL Server database

MasterShip

- www.mastership.nl
- CAD/CAM system for marine engineering, integrated in AutoCAD
- Composed by a SQL database and 4 generation modules:
  - Form generation
  - Parts generation
  - Piping and duct systems generation
  - Generation of NC and nesting data

MAAT 2000

- www.reds-engineering.com
- Modeling the hull form with NURBS surfaces
- Hydrostatic computations
- Modeling of structures
- Production of drawings
- Used by the French Navy