Innovative Ship and Offshore Plant Design

Part I. Ship Design

Ch. 8 Hull Form Design

Spring 2016

Myung-Il Roh

Department of Naval Architecture and Ocean Engineering
Seoul National University

Contents

Ch. 8 Hull Form Design

1. Hull Form and Hull Form Coefficients
2. Hull Form Variation
3. Hull Form Fairing
4. Performance Evaluation of Hull Form
5. Generation of Hull Form Surface
6. Appendage Design
7. Examples of Hull Form Design

1. Hull Form and Hull Form Coefficients

What is a “Hull form”?

☑ **Hull form**

that is streamlined in order to satisfy requirements of a ship owner such as a deadweight, ship speed, and so on

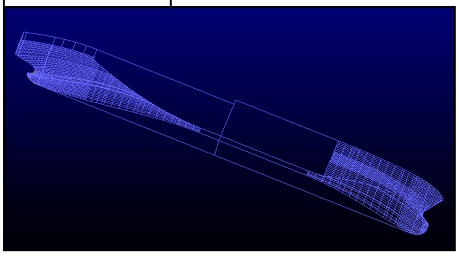
- Like a skin of human

☑ **Hull form design**

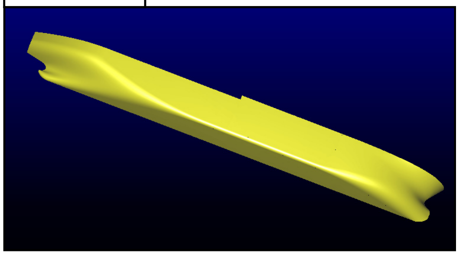
- Design task that designs the hull form

Hull form of the VLCC(Very Large Crude oil Carrier)

Wireframe model

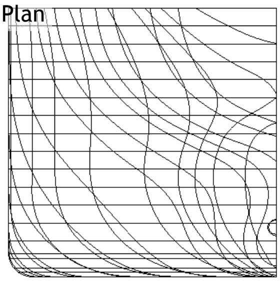


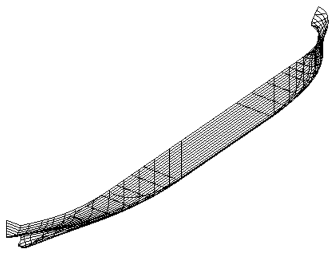
Surface model



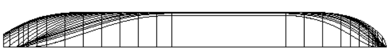
Lines

Body Plan



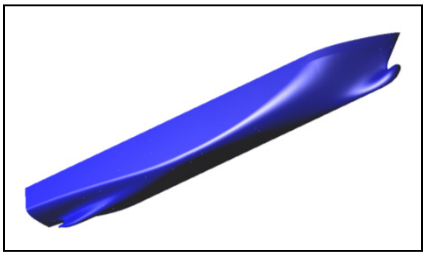


Water Plan

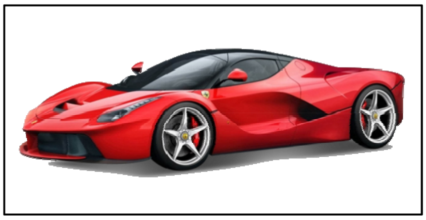


Sheer Plan

Hull Form Design vs. Car Exterior Design

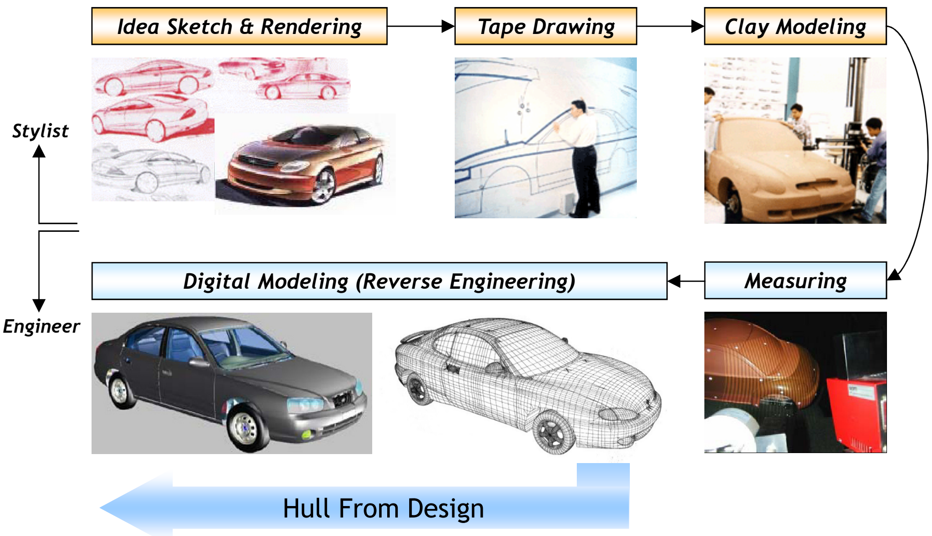


❑ Hull form design
- A hull form is related to **the resistance and propulsion performance** of a ship.
- Order production: new design for each order
- Large structure of about 100~400 m length
- **The performance like speed and deadweight is most important**.

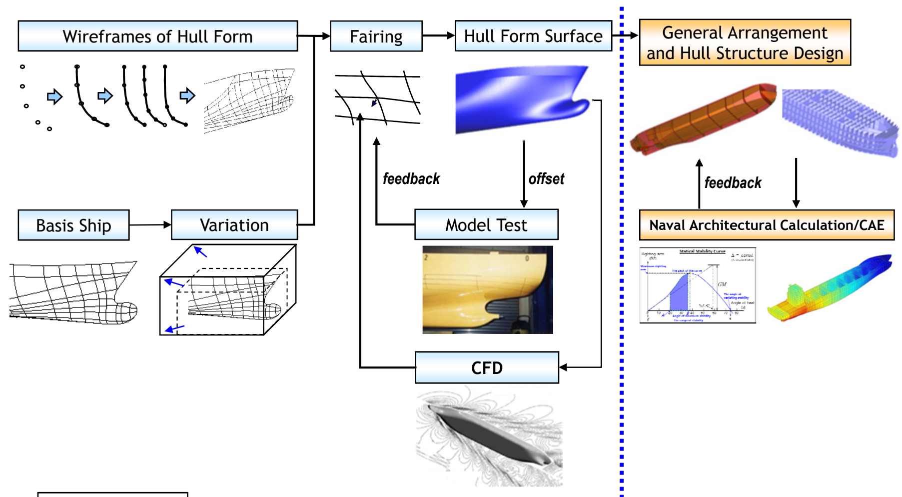


❑ Car exterior design
- A exterior is related to **the air resistance and esthetic design** of a car.
- Mass production: one time design for each model
- **The performance and esthetic design are simultaneously important**.

Procedure of Car Exterior Design



Procedure of Hull Form Design

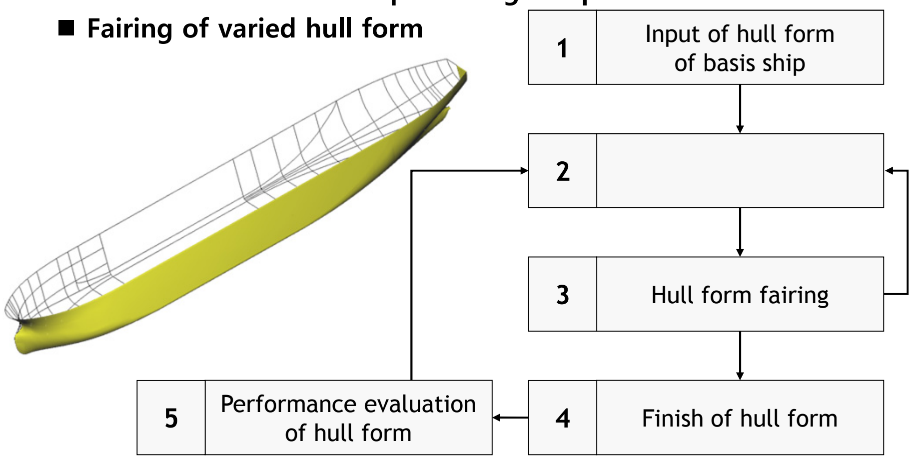


* CFD: Computational Fluid Dynamics, CAE: Computer-Aided Engineering

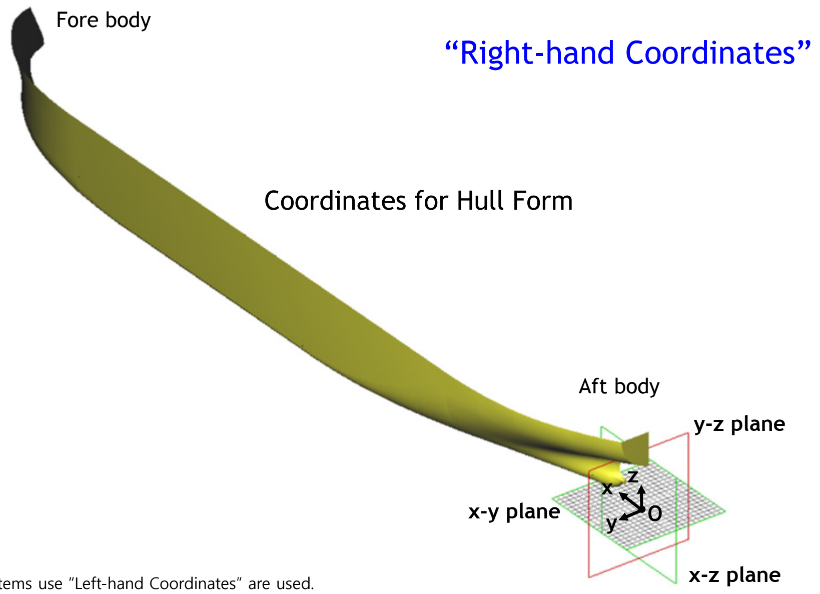
Overview of Hull Form Design

☑ **Procedures of hull form (wire frame) design**

- **Input or generation of hull form of basis ship**
- **Variation from basis ship to design ship**
- **Fairing of varied hull form**



Coordinates for Hull Form Representation



* Some systems use "Left-hand Coordinates" are used.

Composition of Wireframes of Hull Form

☑ **Hull form curves**

- **Primary curves**
  - **They define .**
  - **Profile line, bottom tangent line, side tangent line, etc.**
- **Secondary curves**
  - **They define under the outer shape defined by primary curves.**
  - **Section line, buttock line, water line, space line, etc.**

☑ **Wireframes**

which are generated from primary and secondary curves, and intersection curves among them

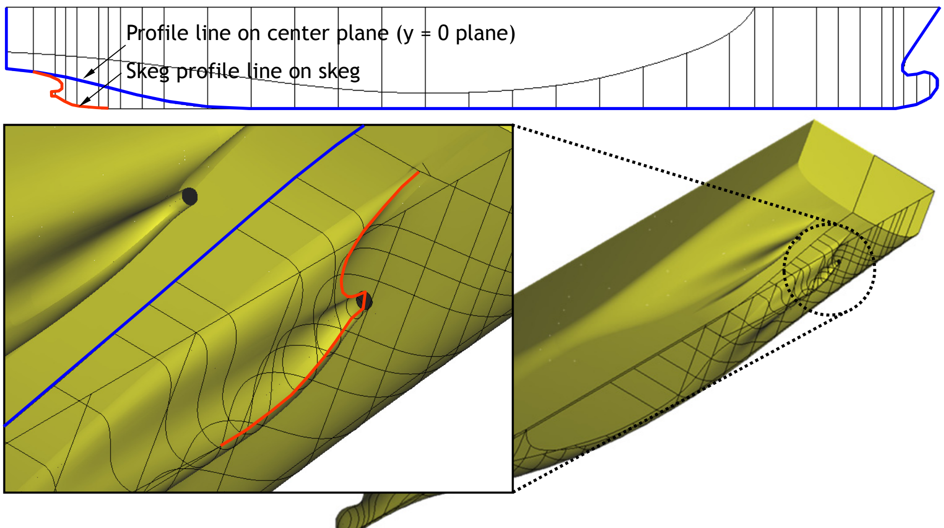
- **They contain a number of closed regions of triangle, quadrilateral, pentagon, etc.**
- **Basis for generating a hull form surface**

Primary Curves for Hull Form Representation - Profile Line (1/2)

- ☑ Profile line is an intersection (or tangent) curve between hull form surface and center plane (center plane, y = 0 plane) except for deck.
- ☑ Also called center line

Example of profile line of a 320K VLCC

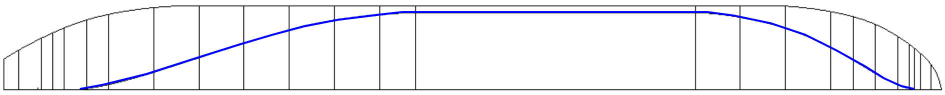
Primary Curves for Hull Form Representation - Profile Line (2/2)



Example of profile line of a twin-skeg container ship

Primary Curves for Hull Form Representation - Bottom Tangent Line

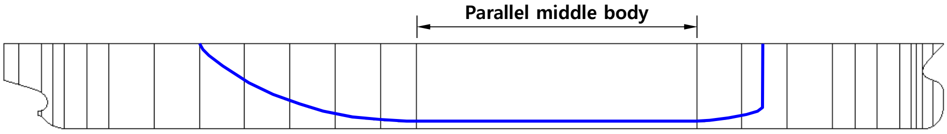
☑ **Bottom tangent line is an intersection (or tangent) curve between hull form surface and base plane (z = 0 plane)**



Example of bottom tangent line of a 320K VLCC

Primary Curves for Hull Form Representation - Side Tangent Line

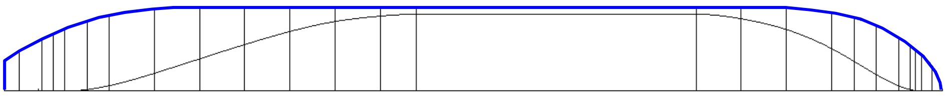
☑ **Side tangent line is an intersection (or tangent) curve between hull form surface and y = $B_{mld}/2$ plane.**



Example of side tangent line of a 320K VLCC

Primary Curves for Hull Form Representation - Deck Side Line

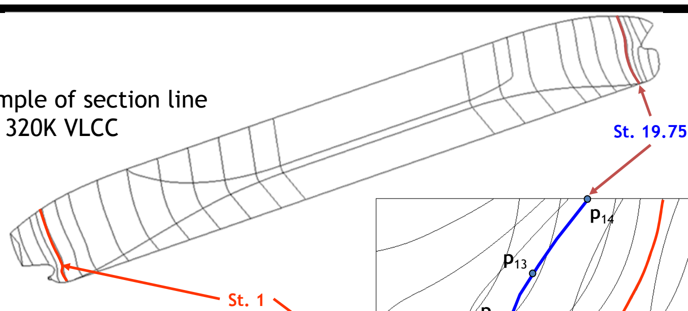
- ☑ Deck side line is a curve representing the side of upper deck
- ☑ Both ends of the curve contact with profile line.

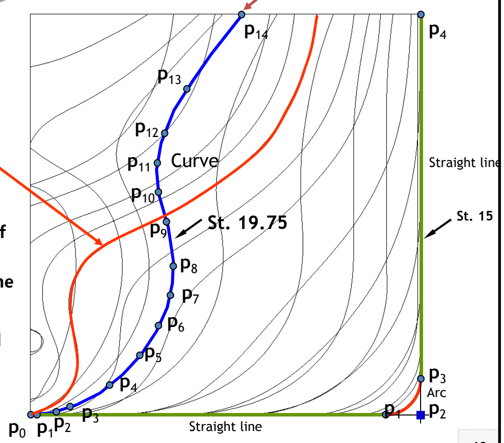


Example of deck side line of a 320K VLCC

Secondary Curves for Hull Form Representation - Section Line

Example of section line of a 320K VLCC

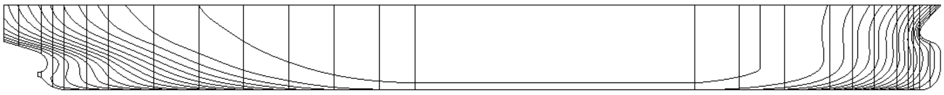




- ☑ Section line is a curve located on a cross (longitudinal) section (y-z plane).
- ☑ Stations are ship hull cross section at a spacing of $L_{BP}/20$, station '0' is located at the aft perpendicular, station '20' at the forward perpendicular. Station '10' therefore represents the midship section.
- ☑ In generally, because the section lines are located at the stations, they are called station line.
- ☑ Section lines make up the body plan of lines.

Secondary Curves for Hull Form Representation - Buttock Line

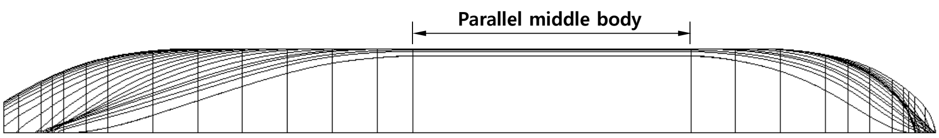
- ☑ **Buttock line is a curve located on a profile (lateral) section (x-z plane).**
- ☑ **Buttock lines make up the or of lines.**



Example of buttock line of a 320K VLCC

Secondary Curves for Hull Form Representation - Water Line

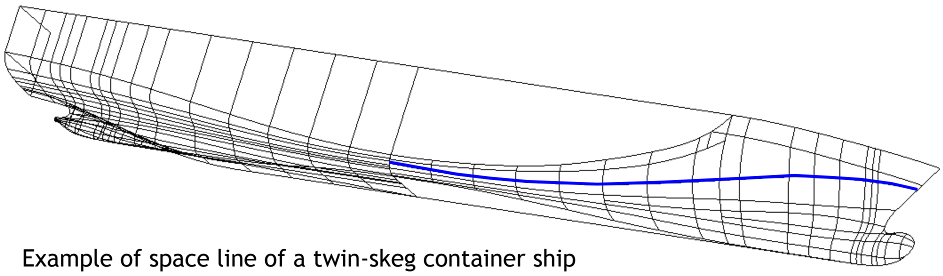
- ☑ **Water line is a curve located on a water plane (vertical) section (x-y plane).**
- ☑ **Water lines make up the or of lines.**



Example of water line of a 320K VLCC

Secondary Curves for Hull Form Representation - Space Line (1/2)

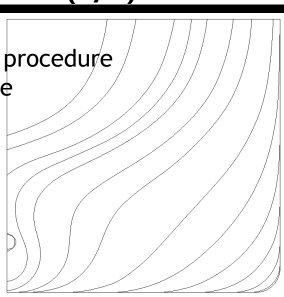
- ☑ Space line is a curve located on a 3D space, as compared with plane curve such as section line, buttock line, water line, etc.
- ☑ For the complicated hull form, space lines are additionally required with plane curves for defining the hull form.



Example of space line of a twin-skeg container ship

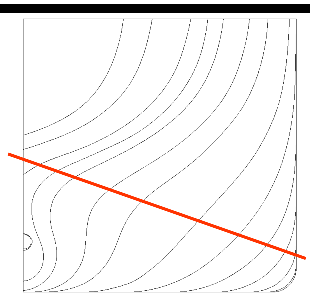
Secondary Curves for Hull Form Representation - Space Line (2/2)

Generation procedure of space line



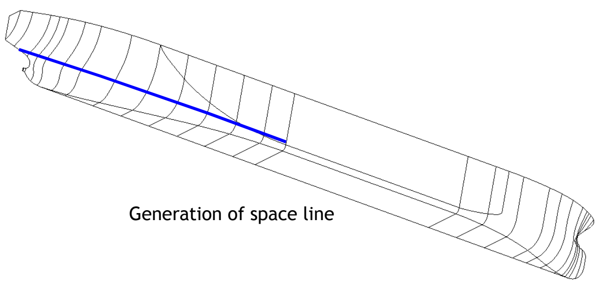
Projection on y-z plane

➡



Generation of 2D auxiliary line

➡



Generation of space line

Generation of Wireframes of Hull From

① Input
- Primary curves, secondary curves

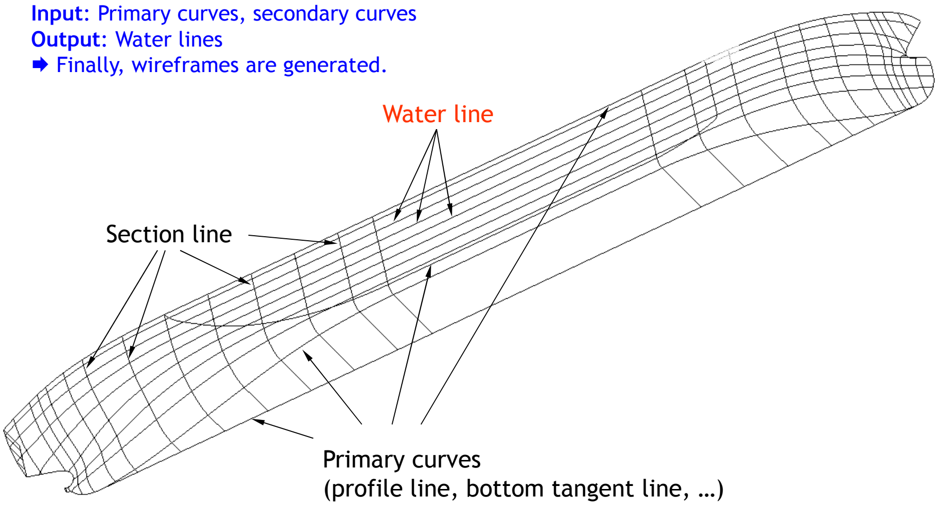
② Intersection
- Generation of intermediate curves such as water lines and buttock lines through intersection between primary and secondary curves

③ Wireframes generation
- Generation of wireframes using ① and ②

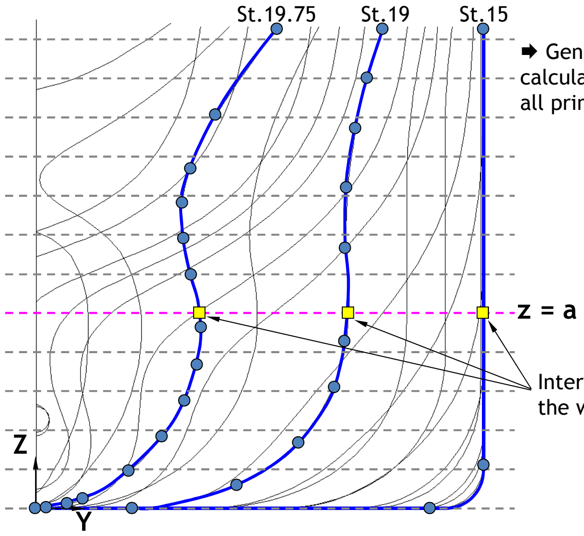
Wireframes Generation

Wireframes generation using primary & secondary curves and water lines

Input: Primary curves, secondary curves
Output: Water lines
➡ Finally, wireframes are generated.

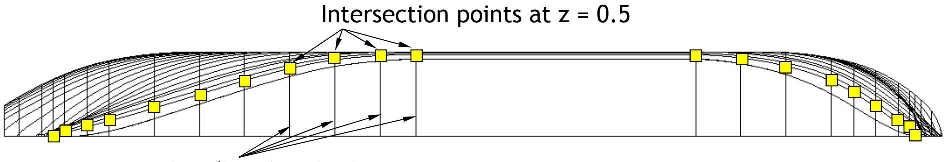


Generation of Water Lines (1/2)



➡ Generate a water line by intersection calculation between 'z = a' plane and all primary curves and section lines.

Generation of Water Lines (2/2)

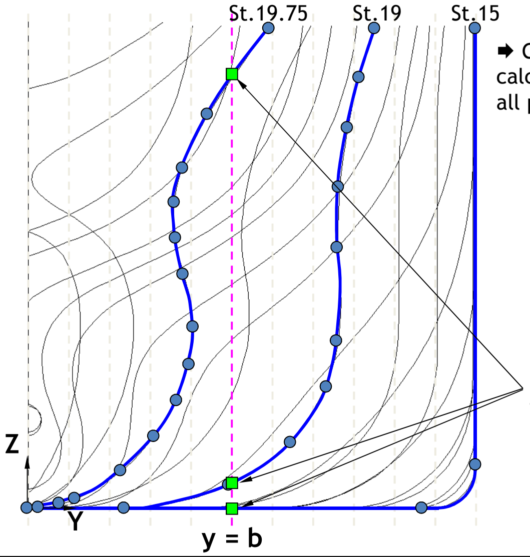


Fitting using a NURB curve with all intersection points at 'z = a'
➡ Generation of a water line at z = a

⬇ Repeat this for the z position what we want.

Generation of water lines

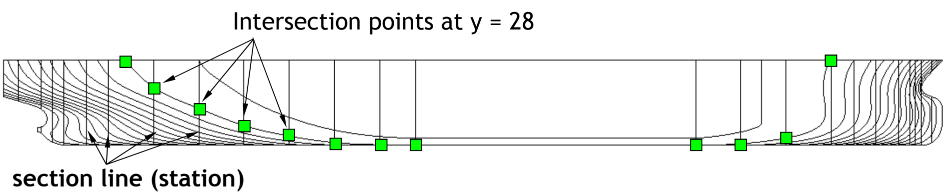
Generation of Buttock Lines (1/2)



➡ Generate a buttock line by intersection calculation between 'y = b' plane and all primary curves and section lines.

Intersection points for generating the buttock line at 'y = b'

Generation of Buttock Lines (2/2)

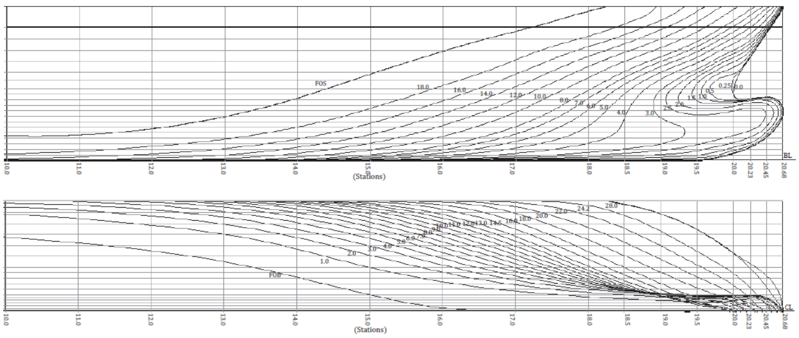
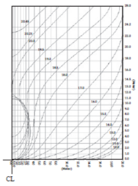


Fitting using a NURB curve with all intersection points at 'y = b'
➡ Generation of a buttock line at y = b

⬇ Repeat this for the y position what we want.

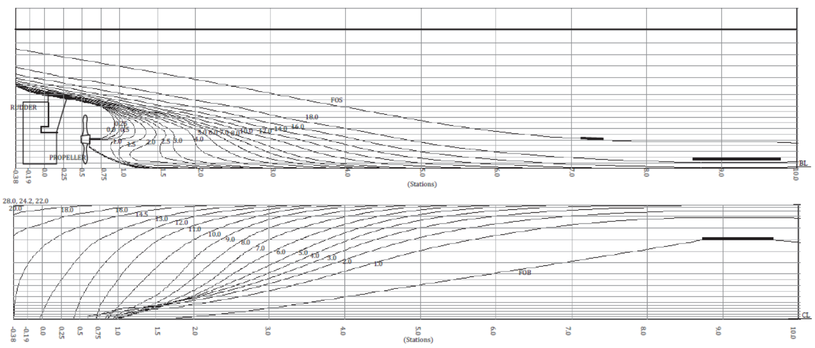
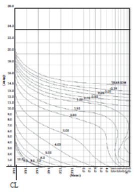
Generation of buttock lines

Example of Lines of a 6,300TEU Container Ship - Fore Body

GENERAL PARTICULARS	
L.O.A (m)	278.05
L.B.P (m)	264.05
B mld (m)	40.0
D mld (m)	24.2
Td mld (m)	12
Ts mls (m)	14.5

Example of Lines of a 6,300TEU Container Ship - After Body

GENERAL PARTICULARS	
L.O.A (m)	278.05
L.B.P (m)	264.05
B mld (m)	40.0
D mld (m)	24.2
Td mld (m)	12
Ts mls (m)	14.5

Example of Offsets Table of a 6,300TEU Container Ship

→ Waterline

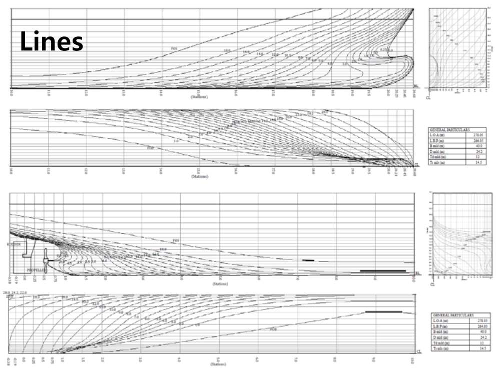
* Unit: mm

↓ Stations

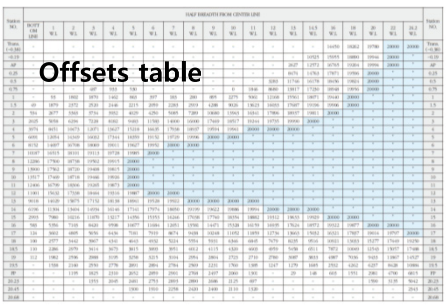
Half-Breadth

Station NO.	HALF BREADTH FROM CENTER LINE																				Station NO.
	BOTTOM LINE	1 W.L	2 W.L	3 W.L	4 W.L	5 W.L	6 W.L	7 W.L	8 W.L	9 W.L	10 W.L	11 W.L	12 W.L	13 W.L	14.5 W.L	16 W.L	18 W.L	20 W.L	22 W.L	24.2 W.L	
Trans. (-0.38)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	14450	18262	19780	20000	20000	Trans. (-0.38)
-0.19	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10525	15955	18890	19944	20000	*	-0.19
AP	-	-	-	-	-	-	-	-	-	-	-	-	-	2627	12572	16765	19204	19994	20000	*	AP
0.25	-	-	-	-	-	-	-	-	-	-	-	-	-	8474	14763	17871	19596	20000	*	*	0.25
0.5	-	-	-	-	-	-	-	-	-	-	-	-	3283	11746	16178	18456	19824	20000	*	*	0.5
0.75	-	-	-	487	933	530	-	-	-	-	0	1846	8680	13817	17230	18948	19956	20000	*	*	0.75
1	-	93	1802	1870	1462	863	397	183	280	895	2275	5061	12168	15561	18071	19440	20000	*	*	*	1
1.5	49	1879	2372	2520	2446	2215	2059	2283	2919	4288	9026	13623	16033	17687	19196	19906	20000	*	*	*	1.5
2	534	2677	3363	3734	3932	4029	4250	5085	7289	10680	13943	16341	17896	18937	19811	20000	*	*	*	*	2
3	2025	5058	6294	7228	8182	9483	11583	14000	16000	17469	18517	19244	19735	19990	20000	*	*	*	*	*	3
4	3974	8451	10473	12071	13627	15218	16635	17938	18937	19594	19941	20000	20000	20000	*	*	*	*	*	*	4
5	6091	12054	14349	16032	17344	18359	19152	19729	19996	20000	20000	*	*	*	*	*	*	*	*	*	5
6	8152	14697	16708	18069	19011	19627	19952	20000	20000	*	*	*	*	*	*	*	*	*	*	*	6
7	10187	16515	18101	19113	19728	19985	20000	*	*	*	*	*	*	*	*	*	*	*	*	*	7
8	12286	17500	18738	19502	19915	20000	*	*	*	*	*	*	*	*	*	*	*	*	*	*	8
9	13900	17562	18720	19408	19815	20000	*	*	*	*	*	*	*	*	*	*	*	*	*	*	9
10	13517	17469	18718	19466	19926	20000	*	*	*	*	*	*	*	*	*	*	*	*	*	*	10
11	12406	16799	18306	19265	19873	20000	*	*	*	*	*	*	*	*	*	*	*	*	*	*	11
12	11001	15632	17338	18464	19316	19887	20000	20000	*	*	*	*	*	*	*	*	*	*	*	*	12
13	9018	14029	15875	17152	18138	18941	19528	19922	20000	20000	20000	20000	*	*	*	*	*	*	*	*	13
14	6196	11304	13404	14934	16146	17141	17974	18650	19199	19622	19886	19994	20000	20000	20000	*	*	*	*	*	14
15	2993	7980	10216	11870	13217	14356	15353	16246	17038	17740	18354	18882	19312	19633	19929	20000	20000	*	*	*	15
16	583	5356	7103	8420	9598	10677	11684	12651	13581	14471	15328	16159	16935	17624	18572	19322	19877	20000	20000	*	16
17	124	3602	4805	5656	6434	7181	7919	8674	9438	10248	11052	11859	12734	13663	15032	16321	17837	19014	19797	20000	17
18	100	2577	3442	3967	4341	4643	4932	5224	5554	5931	6346	6845	7479	8235	9516	10921	13033	15277	17449	19250	18
18.5	110	2286	2979	3414	3673	3815	3893	3951	4012	4115	4320	4603	4959	5458	6511	7872	10049	12543	15057	17488	18.5
19	112	1982	2596	2988	3195	3258	3215	3104	2954	2804	2723	2710	2780	3087	3833	4987	7036	9433	11867	14527	19
19.5	-	1538	2160	2550	2778	2891	2894	2784	2569	2231	1760	1385	1247	1279	1685	2532	4262	6237	8428	10884	19.5
FP	-	-	1195	1825	2310	2652	2859	2901	2768	2497	2060	1301	-	29	148	603	1551	2981	4700	6815	FP
20.23	-	-	-	1353	2045	2481	2753	2893	2890	2686	2125	697	-	-	-	-	-	1590	3135	5042	20.23
20.45	-	-	-	-	-	1300	1910	2258	2420	2400	2110	1320	-	-	-	-	-	-	-	2343	20.45
20.68	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	20.68

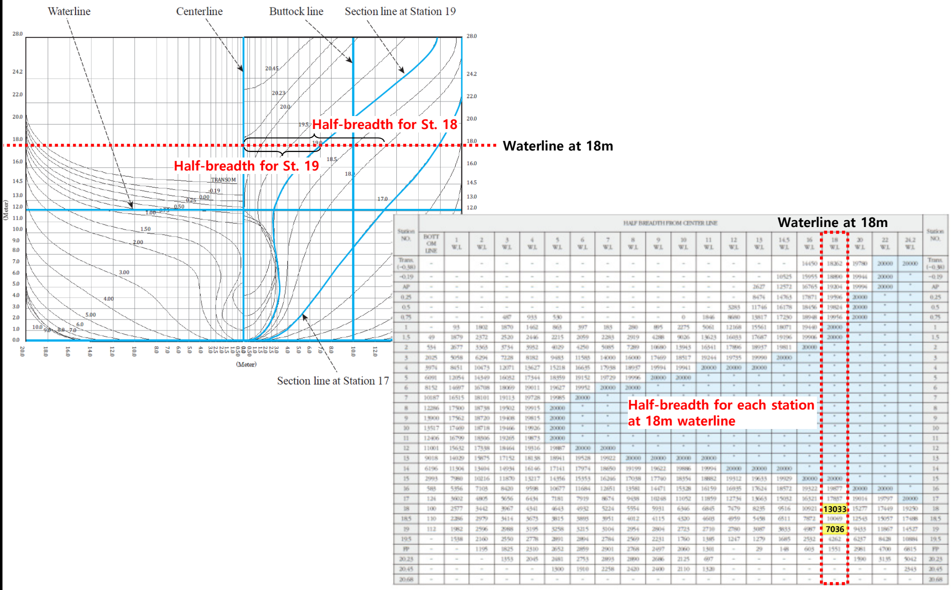
Relationship Between Lines and Offsets Table (1/2)



Generation of offsets table from the lines

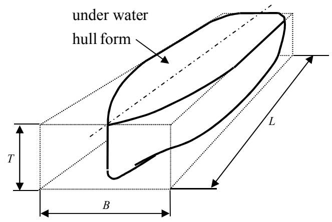


Relationship Between Lines and Offsets Table (2/2)



Hull Form Coefficients
- C_B (Block Coefficient) and C_P (Prismatic Coefficient)

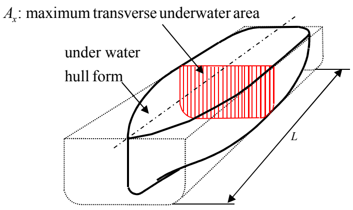
C_B (Block coefficient)



$$C_B = \frac{\nabla}{L \cdot B \cdot T}$$

∇ = moulded volume of displacement
L = length of the ship (L_{BP} or L_{WL})
B = moulded breadth
T = moulded draft

C_P (Prismatic coefficient)

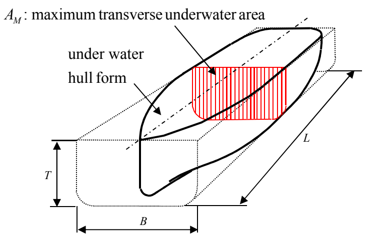


$$C_P = \frac{\nabla}{L \cdot A_M} = \frac{C_B}{C_M}$$

∇ = moulded volume of displacement
L = length of the ship (L_{BP} or L_{WL})
A_M = midship section area
C_M = midship coefficient

Hull Form Coefficients
- C_M (Midship Section Coefficient) and C_{WP} (Water Plane Area Coefficient)

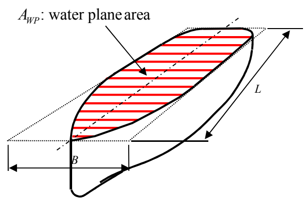
C_M (Midship Section Coefficient)



$$C_M = \frac{A_M}{B \cdot T}$$

A_M = midship section area
B = moulded breadth
T = moulded draft

C_{WP} (Water Plane Area Coefficient)

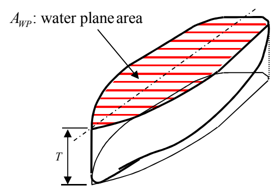


$$C_{WP} = \frac{A_{WP}}{L \cdot B}$$

A_W = water plane area
L = length of the ship (LWL or LBP)
B = moulded breadth

Hull Form Coefficients
- C_{VP} (Vertical Prismatic Coefficient)

C_{VP} (Vertical Prismatic Coefficient)

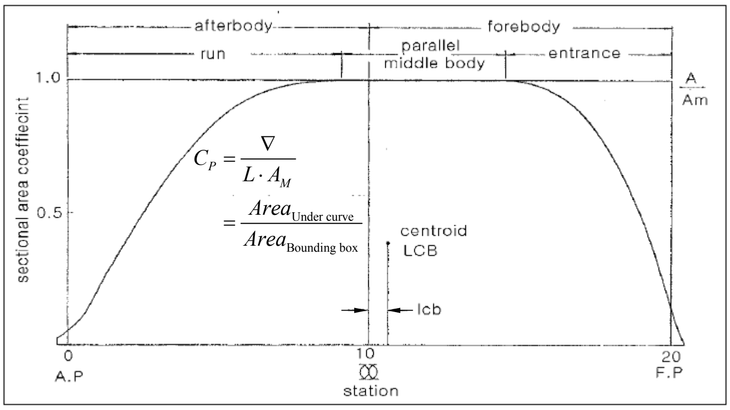


$$C_{VP} = \frac{\nabla}{T \cdot A_{WP}}$$

∇ = moulded volume of displacement
A_{WP} = water plane area
T = moulded draft

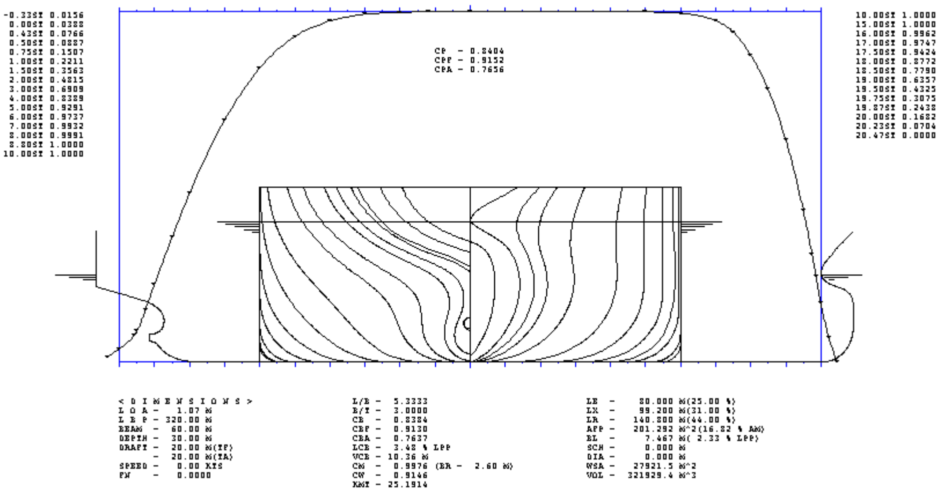
C_P Curve (Sectional Area Curve)

- C_P curve (or sectional area curve) is a diagram of transverse section areas up to the designed water line, plotted on a base on length.
- This diagram may be made dimensionless by plotting each ordinate as the ratio of the area A of any section to the area of the maximum section.
- This diagram represents the



Sectional area curve or C_P-curve and LCB (Longitudinal Center of Buoyancy)

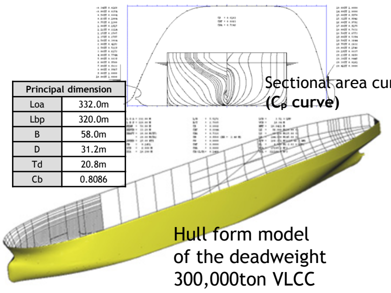
Example of C_P Curve of a 320K VLCC



2. Hull Form Variation

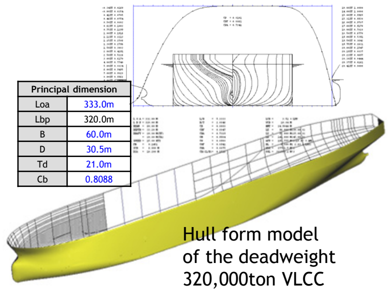
Hull Form Variation (1/2)

☑ Design task for obtaining a hull form of a design ship from the variation of that of a basis ship



Principal dimension	
Loa	332.0m
Lbp	320.0m
B	58.0m
D	31.2m
Td	20.8m
Cb	0.8086

Hull form variation ➡



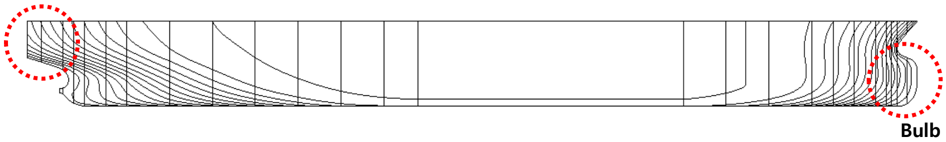
Principal dimension	
Loa	333.0m
Lbp	320.0m
B	60.0m
D	30.5m
Td	21.0m
Cb	0.8088

Hull Form Variation (2/2)

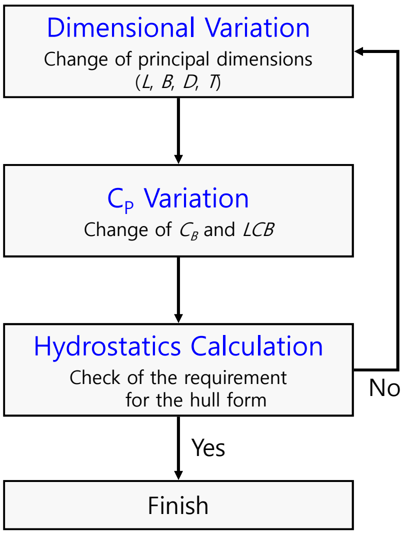
☑ Categorization of Hull Form Methods

- Change of principal dimensions (L_{BP}, B, D, T)
- Change of hull form parameters (e.g, transom height, shaft center height, bossing end radius, maximum deck height, bilge radius, etc.)

- Change of C_B (actually, displacement) and LCB
- Miscellaneous dimensions (e.g., transom length, bulb length, etc.)



Procedure of the Hull Form Variation (Overview)



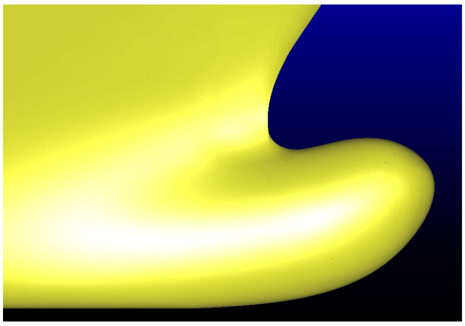
3. Hull Form Fairing

Hull Form Fairing

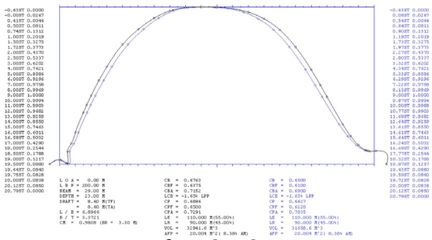
- ☑ Design task for obtaining a hull form of high quality after hull form variation
- ☑ A kind of touch-up process for the hull form
- ☑ Quality check by using C_P curve

Example of Hull Form of High Quality

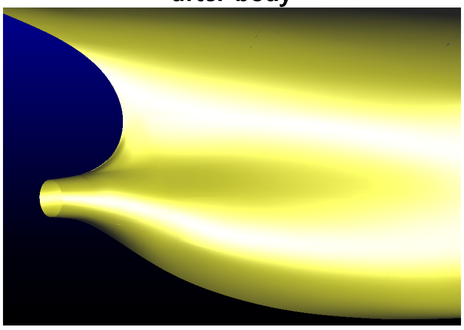
Example of a single skeg container ship



Fore body

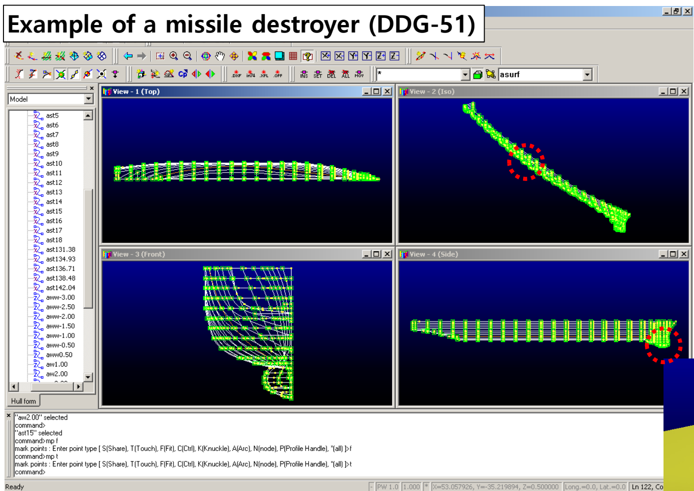


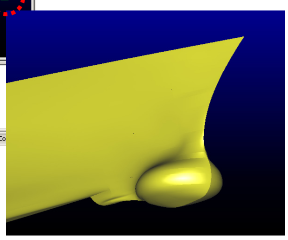
after body



Example of Hull Form of Low Quality (1/2)

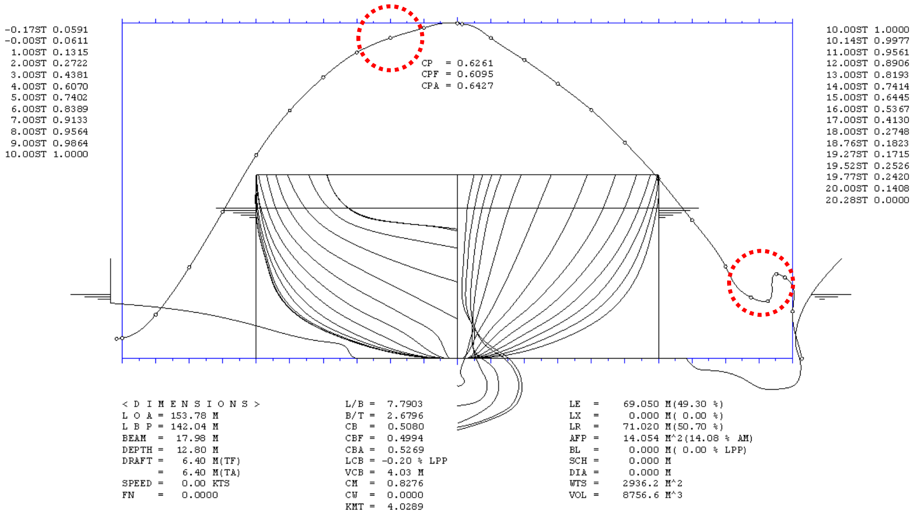
Example of a missile destroyer (DDG-51)





Example of Hull Form of Low Quality (2/2)

Example of a missile destroyer (DDG-51)



4. Performance Evaluation of Hull Form

Performance Evaluation of a Hull Form

- Hull form coefficients
- Hydrostatic tables and hydrostatic curves

- Traditional and standard series methods
- Regression based methods (Statistical methods)
- Direct model test
- Computational Fluid Dynamics (CFD)

- Dependent on couple effect between hull form and rudder

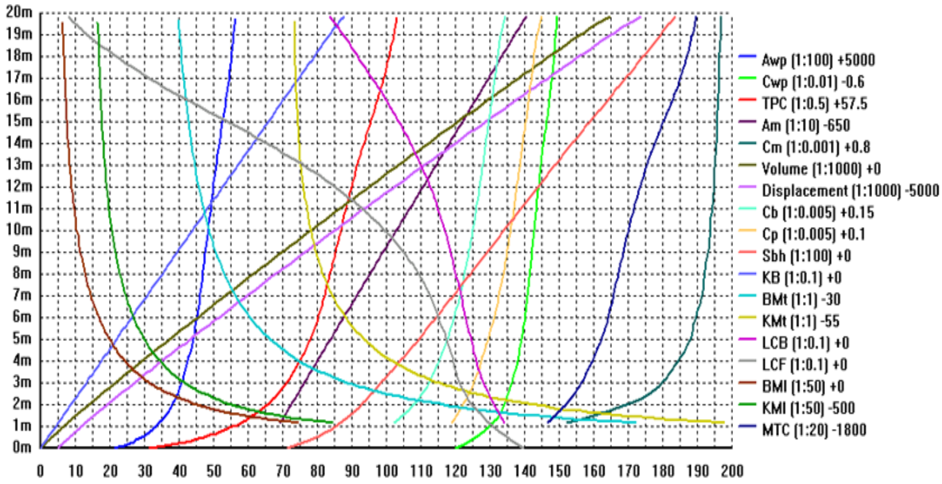
Stability Performance - Hydrostatic Values

- ☑ $Draft_{Mld}$, $Draft_{Scant}$: Draft from base line, moulded / scantling (m)
- ☑ $Volume_{Mld}(\nabla)$, $Volume_{Ext}$: Displacement volume, moulded / extreme (m^3)
- ☑ $Displacement_{Mld}(\Delta)$, $Displacement_{Ext}$: Displacement, moulded / extreme (ton)
- ☑ LCB: Longitudinal center of buoyancy from midship (Sign: - Aft / + Forward)
- ☑ LCF: Longitudinal center of floatation from midship (Sign: - Aft / + Forward)
- ☑ VCB: Vertical center of buoyancy above base line (m)
- ☑ TCB: Transverse center of buoyancy from center line (m)
- ☑ KM_T: Transverse metacenter height above base line (m)
- ☑ KM_L: Longitudinal metacenter height above base line (m)
- ☑ MTC: Moment to change trim one centimeter (ton-m)
- ☑ TPC: Increase in $Displacement_{Mld}$ (ton) per one centimeter immersion
- ☑ WSA: Wetted surface area (m^2)
- ☑ C_B: Block coefficient
- ☑ C_{WP}: Water plane area coefficient
- ☑ C_M: Midship section area coefficient
- ☑ C_P: Prismatic coefficient
- ☑ Trim: Trim(= after draft – forward draft) (m)

Stability Performance
- Hydrostatic Curve

☑ Hydrostatic curve: Curve for representing hydrostatic values

Example of Hydrostatic Curve



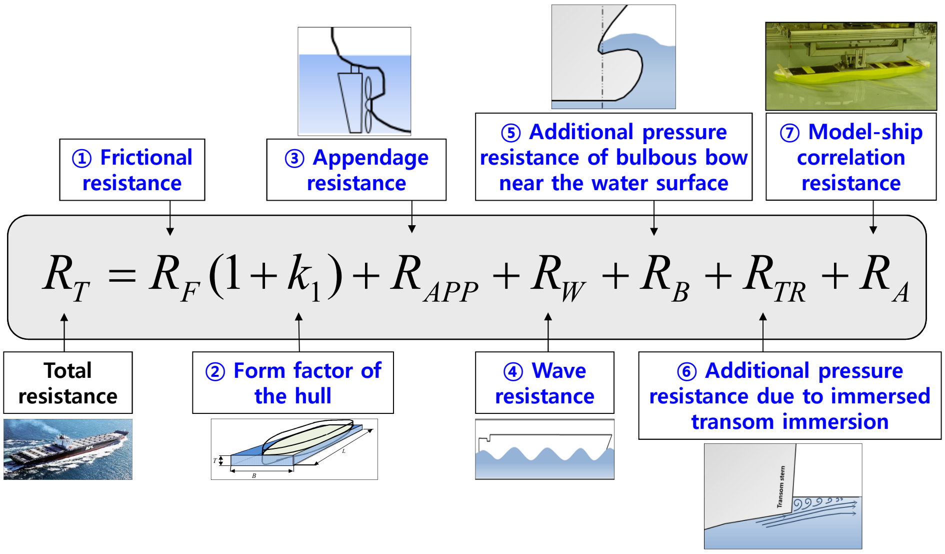
Resistance Performance
- Types of Ship Resistance Evaluation Methods

Ship resistance evaluation methods

- **Traditional and standard series methods**
  - Taylor
  - Ayre
  - Lap
  - Auf'm Keller
  - Harvald
  - BSRA series
  - SSPA series
  - Series 60
  - Coaster series
  - ⋮
- **Regression based methods**
  - Scott
  - Holtrop & Mennen
  - ⋮
- **Direct model test**
  - 2D extrapolation
  - 3D extrapolation
  - ⋮
- **Computational Fluid Dynamics (CFD)**
  - Advanced Navier-Stokes solution capabilities for 3D flow around ships
  - ⋮

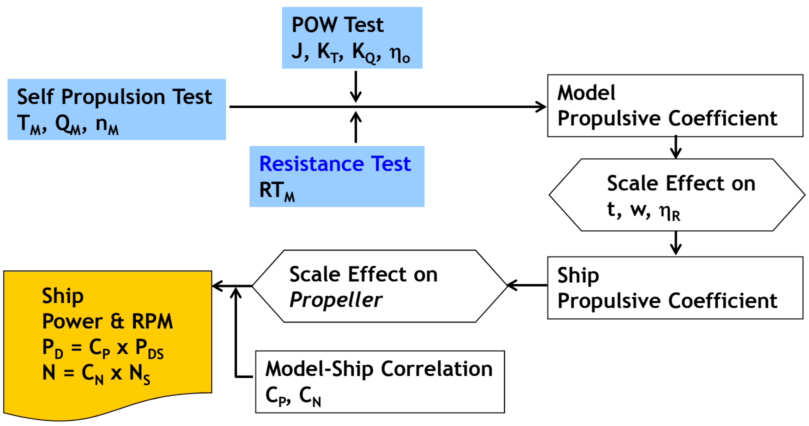
* John Carlton, Marine Propellers and Propulsion, 3rd Edition, Elsevier, 2012

Resistance Performance
- Formula Proposed by Holtrop & Mennen



$$R_T = R_F(1+k_1) + R_{APP} + R_W + R_B + R_{TR} + R_A$$

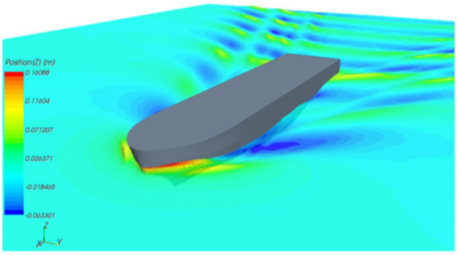
Resistance Performance
- Model Test in the Towing Tank



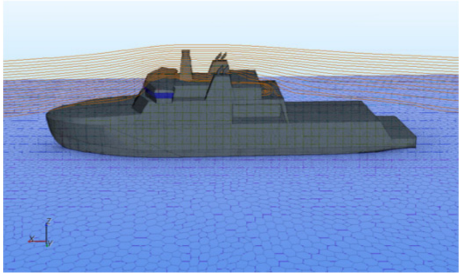
Resistance Performance
- Computational Fluid Dynamics (CFD)

☑ A branch of fluid mechanics that uses numerical methods and algorithms to solve and analyze problems that involve fluid flows

☑ Computers are used to perform the calculations required to simulate the interaction of liquids and gases with surfaces defined by boundary conditions.



Resistance test using CFD to optimize hull form



Aerodynamic analysis of turbulence levels over the helicopter flight deck

* Reference: STX Canada, US Marine

Maneuvering Performance
- Maneuverability

☑ Key measures of maneuvering capability
- Turning ability
- Course changing and Yaw checking ability
- Stopping ability
- Straight line stability and course keeping ability

☑ A hydrodynamic derivatives of ship are required to predict numerically its maneuvering capability.

Maneuvering Performance - Methods for Estimating Maneuvering Capability

☑ Regression Analysis Results from Similar Ships (Semi-empirical Methods)

☑ Theoretical Prediction Methods

☑ Model Tests (Experiments with Scale Models)
- Straight line test
- Rotating arm test
- Planar Motion Mechanism (PMM) test
- Free running (radio controlled) model test

☑ Full Scale Tests
- Tests of adherence to classification society standard

Maneuvering Performance - Standards and Criteria of Maneuverability

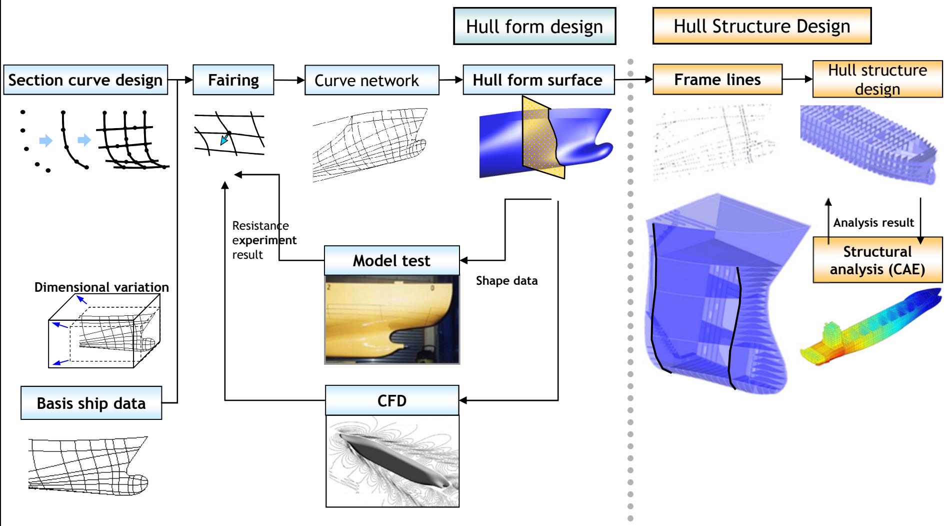
Measure of Maneuverability	*Criteria and Standard*	*Maneuver*	*IMO Standard*	*ABS Guide Requirement*
Required for Optional Class Notation				
Turning Ability	Tactical Diameter	Turning Circle	$TD < 5L$	Rated $Rtd \geq 1$
	Advance		$Ad < 4.5L$	Not rated $Ad < 4.5L$
Course Changing and Yaw Checking Ability	First Overshoot Angle	10/10 Zig-zag test	$\alpha 10_1 \leq f_{101}(L/V)$	Rated $Rt\alpha_{10} \geq 1$
	Second Overshoot Angle		$\alpha 10_2 < f_{102}(L/V)$	Not rated $\alpha 10_2 < f_{102}(L/V)$
	First Overshoot Angle	20/20 Zig-zag test	$\alpha 20_1 \leq 25$	Rated $Rt\alpha_{20} \geq 1$
Initial Turning Ability	Distance traveled before 10-degrees course change	10/10 Zig-zag test	$\ell_{10} \leq 2.5L$	Rated $Rti \geq 1$
Stopping Ability	Track Reach	Crash stop	$TR < 15L$ (1)	Not rated $TR < 15L$ (1)
	Head Reach		None	Rated $Rts \geq 1$
Recommended, Not Required for Optional Class Notation				
Straight-line Stability and Course Keeping Ability	Residual turning rate	Pull-out test	$r \neq 0$	Not rated $r \neq 0$
	Width of instability (2) loop	Simplified spiral	$\alpha_U \leq f_u(L/V)$	Not rated $\alpha_U \leq f_u(L/V)$

Note) 1: For large, low powered vessels, $TR < 20L$. 2: Applicable only for path-unstable vessels.

* Reference: ABS, Guide for Vessel Maneuverability, 2006

5. Generation of Hull Form Surface

Ship Shape ("Hull Form") Design



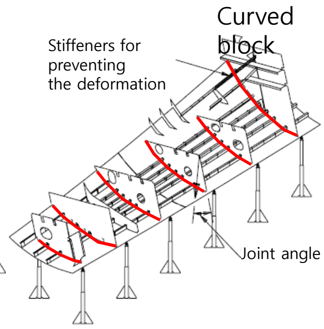
* CFD: Computational Fluid Dynamics, CAE: Computer-Aided Engineering

Needs of the Hull Surface Modeling

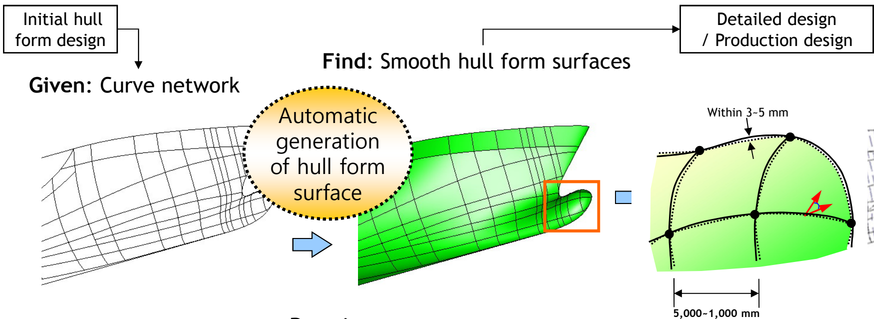
☑ The important production information such as joint length (welding length), painting area, weight, and CG of the building blocks should be estimated at the initial design stage.

☑ For this, we need the hull surface modeling not hull curve modeling.

☑ Furthermore, the estimation of the cost and duration of the construction, the jig information for the fixed curved block can be estimated.



Quality Requirement of a Hull Form Surface



- Irregular topology
- In the form of non-uniform B-spline curves

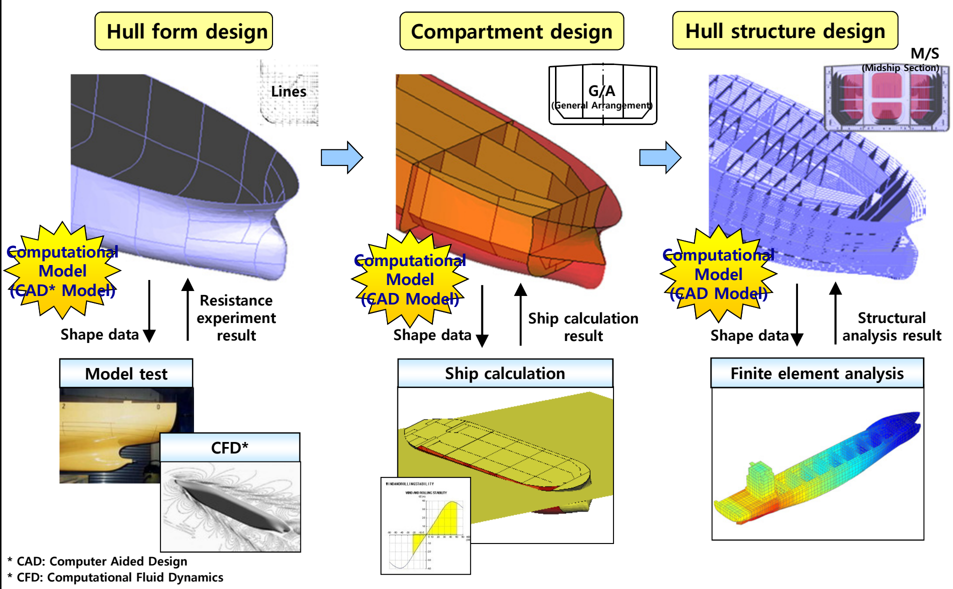
Requirements

- In the form of Bicubic B-spline surface patches
- Max. distance error between given curve network and generated surface < tolerance*
- Smoothness: exact or close to G^1**

- Intersection between surfaces and plane
- Validation of the fairness

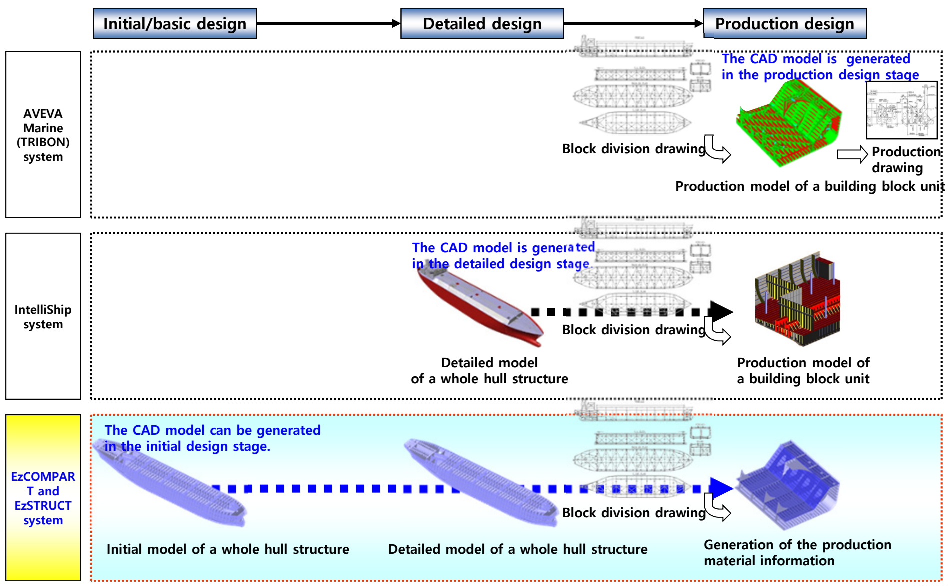
* Acceptable tolerance in shipbuilding industry is about 3~5 mm.
** G^1 means geometric continuity or tangential plane continuity. IntelliShip requires exact G^1 hull form surfaces.

Initial or Basic Design Stage of a Ship



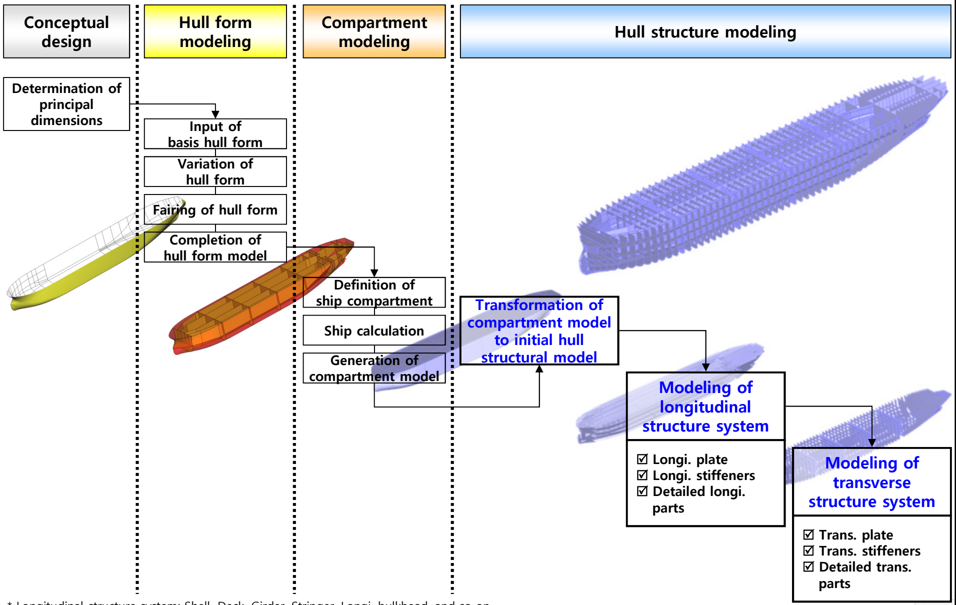
* CAD: Computer Aided Design
* CFD: Computational Fluid Dynamics

Design Stages and CAD Systems for a Ship



* TRIBON: CAD system (the exclusive use of shipbuilding), developed by Product of TRIBON Solution in Sweden
* IntelliShip: M-CAD systmem(the exclusive use of shipbuilding), co-developed by Intergraph, Samsung Heavy Industries, Odense shipyard in Denmark, and Hitachi Shipyard in Japan

Modeling Stages of the Initial or Basic Design



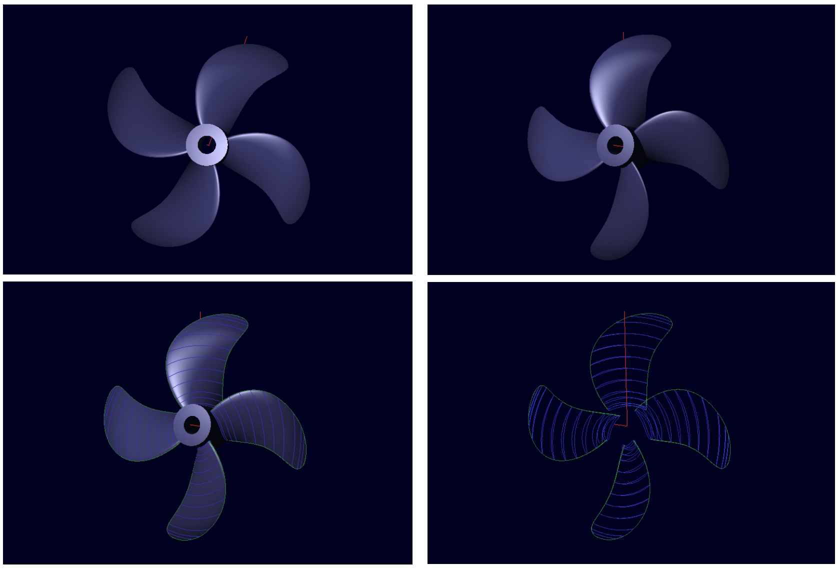
* Longitudinal structure system: Shell, Deck, Girder, Stringer, Longi. bulkhead, and so on
* Transverse structure system: Trans. bulkhead, Web frame, and so on

6. Appendage Design

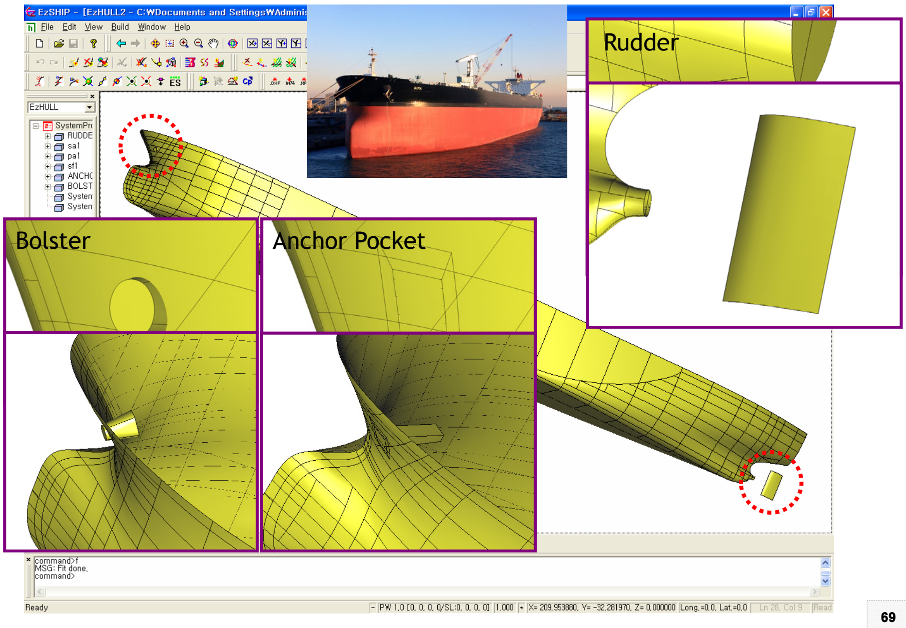
Appendage Design
- Example of a Propeller

- ☑ Ship: 4,900 TEU Container Ship
- ☑ Owner: NYK, Japan
- ☑ Shipyard: HHI (2007.7.20)
- ☑ Diameter: 8.3 m
- ☑ Weight: 83.3 ton
- ☑ No of Blades: 5

Appendage Design
- Propeller



Appendage Design
- Design of Bolster, Anchor Pocket, and Rudder



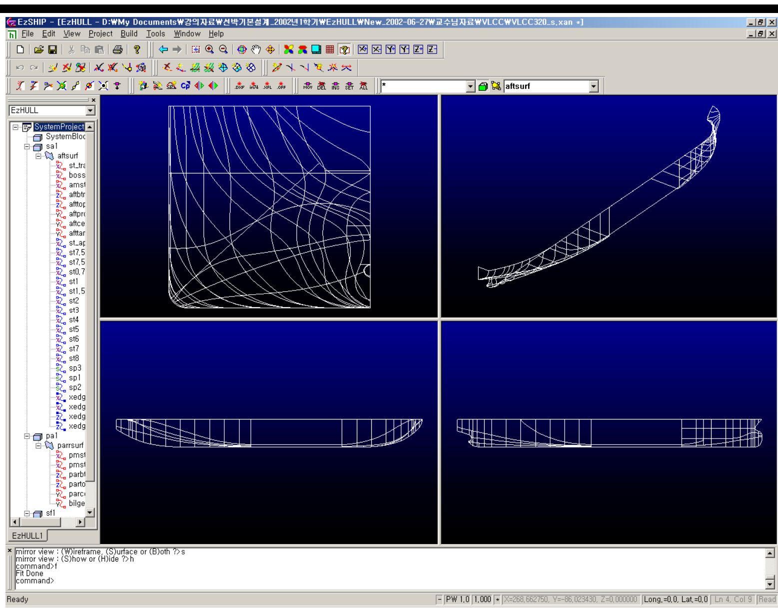
7. Examples of Hull Form Design

Hull Form Design of a 320K VLCC

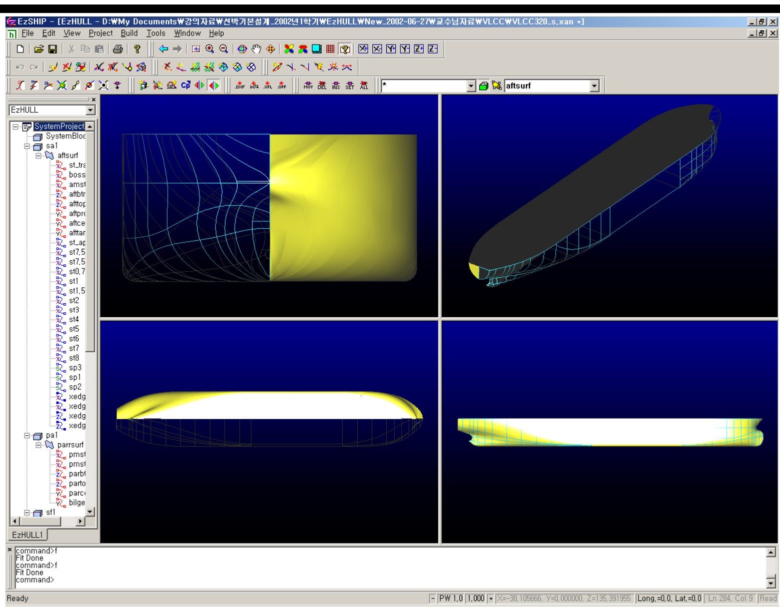
Principal Particulars

Item		Value	Remark
Principal Dimensions	LOA	332.0 m	
	LBP	320.0 m	
	B	60.0 m	
	D	30.5 m	
	Td / Ts	21.0 / 22.5 m	
Cargo Capacity		320,000 MT	at Ts
Speed		16 knots	at Td
Main Engine	Type	SULZER 7RTA84T-D	
	MCR	39,060 PS x 76.0 rpm	
	NCR	35,150 PS x 73.4 rpm	
Propeller Diameter		10.2 m	

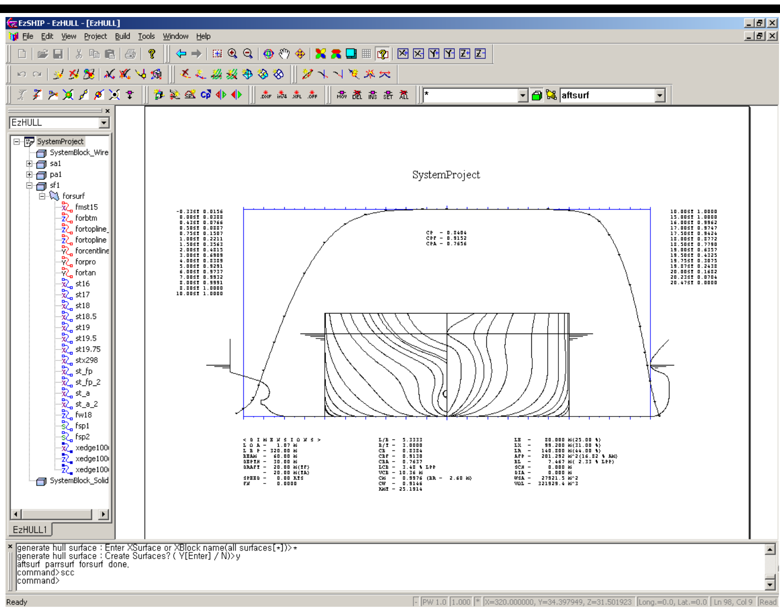
Hull Form Design of a 320K VLCC - Wireframe Model



Hull Form Design of a 320K VLCC
- Surface Model



Hull Form Design of a 320K VLCC
- C_P Curve

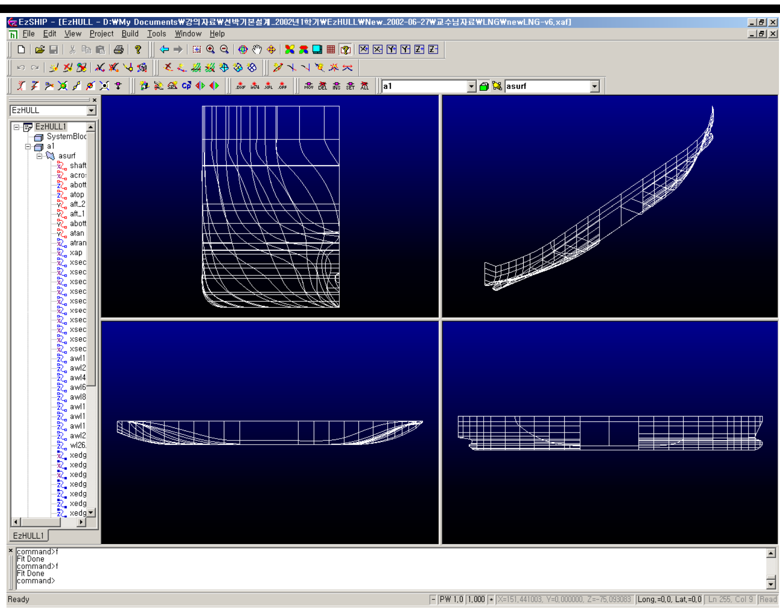


Hull Form Design of a 145K CBM LNGC

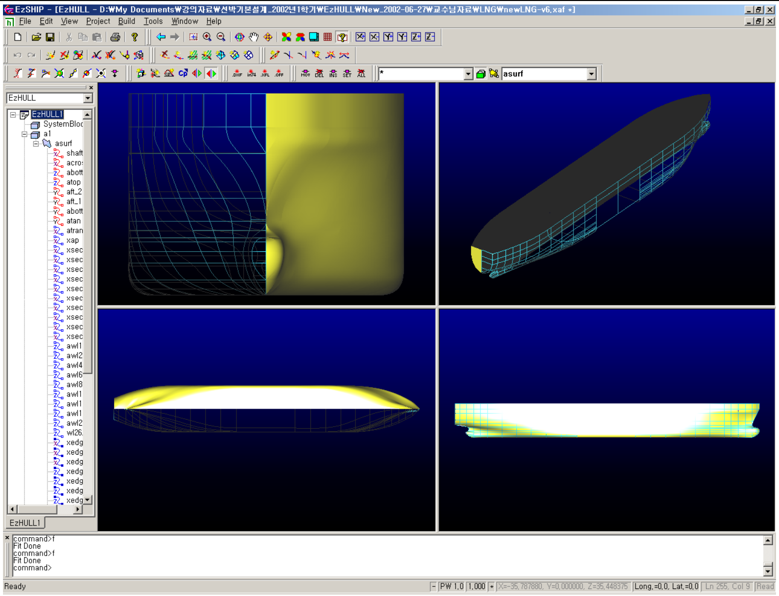
Principal Particulars

Item		Value	Remark
Principal Dimensions	LOA	282.6 m	
	LBP	271.6 m	
	B	43.4 m	
	D	26.5 m	
	Td / Ts	11.3 / 12.0 m	
Cargo Capacity		145,216 CBM	at Td
Speed		20.2 knots	at Td
Main Engine	Type	Mitsubishi MS 40-2	
	MCR	38,709 PS x 83.0 rpm	
	NCR	34,838 PS x 80.0 rpm	
Propeller Diameter		8.28 m	

Hull Form Design of a 145K CMB LNGC
- Wireframe Model



Hull Form Design of a 145K CMB LNGC - Surface Model

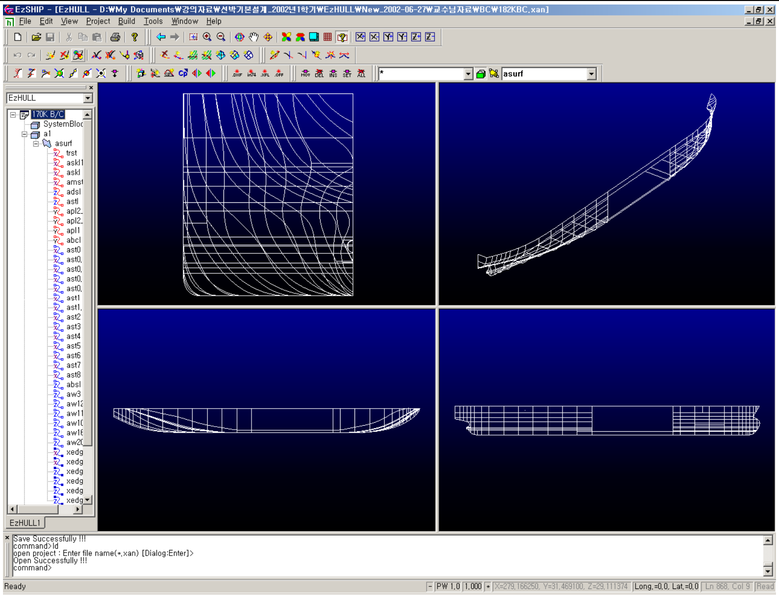


Hull Form Design of a 182K Bulk Carrier

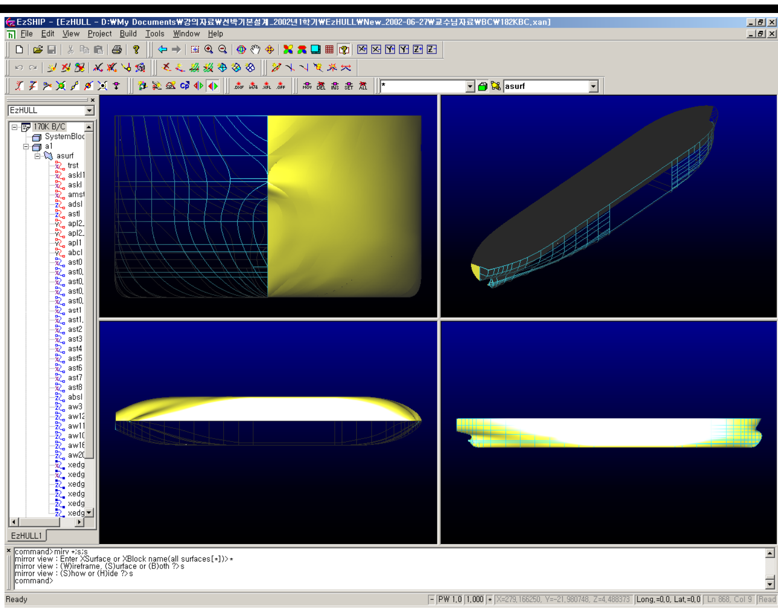
Principal Particulars

Item		Value	Remark
Principal Dimensions	LOA	292.85 m	
	LBP	282.7 m	
	B	46.7 m	
	D	25.8 m	
	Td / Ts	17.9 / 17.9 m	
Cargo Capacity		182,000 MT	at Td
Speed		14.5 knots	at Td
Main Engine	Type	B&W 7S60MC-C	
	MCR	17,940 BHP x 93.0 rpm	
	NCR	15,249 BHP x 84.5 rpm	
Propeller Diameter		7.91 m	

Hull Form Design of a 182K Bulk Carrier - Wireframe Model



Hull Form Design of a 182K Bulk Carrier - Surface Model

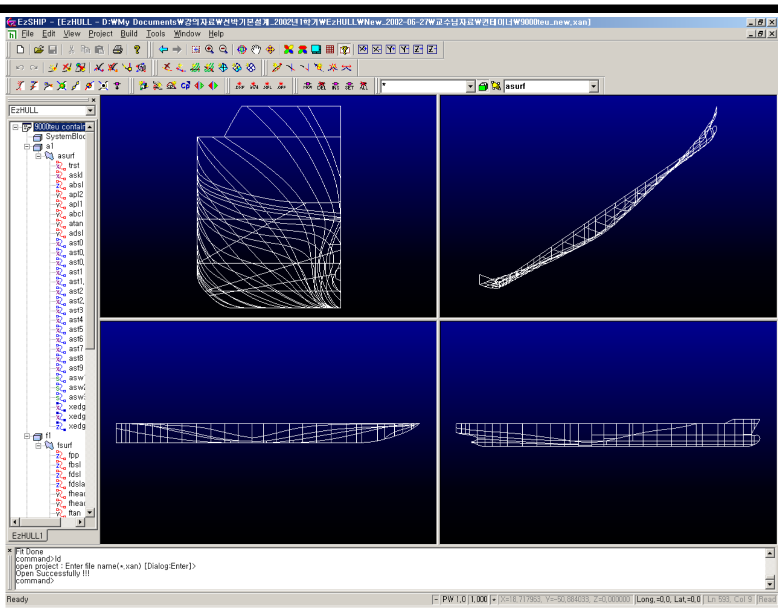


Hull Form Design of a 9,000 TEU Container Ship

Principal Particulars

Item		Value	Remark
Principal Dimensions	LOA	356.18 m	
	LBP	341.18 m	
	B	45.3 m	
	D	27.0 m	
	Td / Ts	14.0 / 14.0 m	
Cargo Capacity		9,012 TEU	at Td
Speed		25.0 knots	at Td
Main Engine	Type	HSD B&W 12K98MC-C	
	MCR	91,491 PS x 94.0 rpm	
	NCR	77,767 PS x 89.0 rpm	
Propeller Diameter		9.70 m	

Hull Form Design of a 9,000 TEU Container Ship - Wireframe Model



Hull Form Design of a 9,000 TEU Container Ship
- Surface Model