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JETM – May 7th, 2018

Eng.º José Cruz, ONE OCEAN

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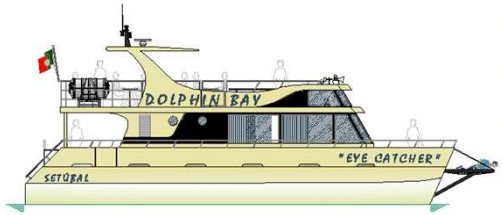
75 PAX COASTAL CATAMARAN DESIGN



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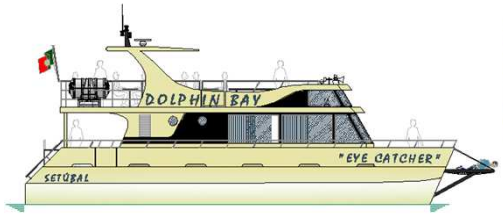
1st Stage – Conceptual Design

Shipyard/Owner concept discussion:

- CONCEPT DESIGN FOR 2 SISTER UNITS
- ALUMINIUM HULL & GFRP SUPERSTRUCTURE;
- COASTAL OPERATION ONLY;
- EQUAL HULL DESIGN, BUT DIFFERENT IN:
  - SUPERSTRUCTURE DESIGN;
  - PROPULSION SYSTEM;
- 1 CAT OF THE 2 CATS TO BE OPERATED WITH ELECTRIC MOTORS;
- MAXIMUM LOA: **16 m**;
- BOTH VESSELS WITH UNDERWATER VIEW PORTS;
- ABLE TO CARRY 75 PAX & 3 CREW;
- CONSTRUCTED IN 3 BLOCKS (PS HULL + SB HULL + CL BLOCK);

Coastal Catamaran Design



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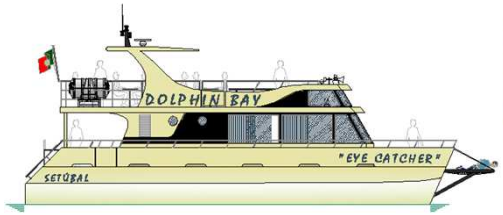
Design Planning

Planeamento CAT 16m

ID	Task Name	Duration	Start	Finish	Predecessors
1	**Trabalho Inicial**	**8 days**	**Thu 15-09-16**	**Mon 26-09-16**	
2	Assinatura de Contrato	1 day	Thu 15-09-16	Thu 15-09-16	JC
3	Especificação Técnica	3 days	Fri 16-09-16	Tue 20-09-16	LC 2
4	Arranjo Geral (Preliminar)	3 days	Fri 16-09-16	Tue 20-09-16	ML
5	Diagrama de Sistemas (Preliminar)	4 days	Wed 21-09-16	Mon 26-09-16	LC 4
6	Modelação de Casco DEFHULL	2 days	Wed 21-09-16	Thu 22-09-16	ML 4
7	Estabilidade	1 day	Fri 23-09-16	Fri 23-09-16	ML 6
8	**1ª Fase: Entrega de Documentos**	**21 days**	**Tue 27-09-16**	**Tue 25-10-16**	1
9	Minuta de traçado	1 day	Tue 27-09-16	Tue 27-09-16	LC 7
10	Plano Geométrico	1 day	Wed 28-09-16	Wed 28-09-16	LC 9
11	Dimensionamento da SM	2 days	Tue 27-09-16	Wed 28-09-16	ML
12	Plano de Secção Mestra	2 days	Thu 29-09-16	Fri 30-09-16	ML 11
13	Plano de Secções Transversais	8 days	Mon 03-10-16	Wed 12-10-16	ML 12
14	Plano de Corte Longitudinal	4 days	Thu 29-09-16	Tue 04-10-16	LC 10
15	Plano de Pavimentos	4 days	Wed 05-10-16	Mon 10-10-16	LC 14
16	Plano de Pés de Carneiro	1 day	Tue 11-10-16	Tue 11-10-16	ML 15
17	Plano da Estrutura de Proa	4 days	Wed 12-10-16	Mon 17-10-16	ML 16
18	Plano da Estrutura de Popa	4 days	Tue 18-10-16	Fri 21-10-16	ML 17
19	Plano da Superestrutura	5 days	Tue 11-10-16	Mon 17-10-16	LC 15
20	Fixes do motor	2 days	Mon 24-10-16	Tue 25-10-16	ML 18
21	Plano de Capacidades	1 day	Tue 18-10-16	Tue 18-10-16	LC 19
22	Plano de Marcas de Calados	1 day	Wed 19-10-16	Wed 19-10-16	LC 21
23	**2ª Fase: Início da Preparação**	**18 days**	**Wed 26-10-16**	**Fri 18-11-16**	8
24	Modelo Preparação DEFSHELL	3 days	Wed 26-10-16	Fri 28-10-16	ML
25	Modelo Preparação DEFSTRUCT	15 days	Mon 31-10-16	Fri 18-11-16	LC 24
26	Modelo 3D autocad	5 days	Mon 31-10-16	Fri 04-11-16	ML 24
27	Divisão de Blocos	1 day	Mon 07-11-16	Mon 07-11-16	ML 26
28	Caderno de Soldadura	2 days	Tue 08-11-16	Wed 09-11-16	ML 27
29	**3ª Fase: Início do Corte e produção**	**15 days**	**Mon 14-11-16**	**Fri 02-12-16**	23FS-5 days
30	Planos de Corte e Produção	15 days	Mon 14-11-16	Fri 02-12-16	ML,L
31	**4ª Fase: Entrega de Documentos**	**21 days?**	**Mon 05-12-16**	**Mon 02-01-17**	29
32	Plano de Portas e Escotilhas	2 days	Mon 05-12-16	Tue 06-12-16	LC
33	Plano do Hélice, Tubeira e Veio Propul	2 days	Mon 05-12-16	Tue 06-12-16	ML
34	Plano de expansão do costado	2 days	Wed 07-12-16	Thu 08-12-16	ML 33
35	Plano de Agulha Magnética	1 day	Wed 07-12-16	Wed 07-12-16	LC 32
36	Plano de Faróis e Antenas	2 days	Thu 08-12-16	Fri 09-12-16	LC 35
37	Plano de Segurança e Salvamento	1 day	Fri 09-12-16	Fri 09-12-16	ML 34
38	Plano de Combate a Incêndios	1 day	Mon 12-12-16	Mon 12-12-16	ML 37
39	Plano de Sondas, Respiros e embornais	1 day	Mon 12-12-16	Mon 12-12-16	LC 36
40	Plano de radiocomunicações	1 day?	Tue 13-12-16	Tue 13-12-16	ML 38
41	Esquema de Refrigeração de Agua Salg	3 days	Mon 12-12-16	Wed 14-12-16	LC 38
42	Esquema de Esgoto, Incêndio e Lastro	5 days	Thu 15-12-16	Wed 21-12-16	LC 41
43	Esquema de Águas Sanitárias	3 days	Thu 22-12-16	Mon 26-12-16	LC 42
44	Esquema de Combustível	3 days	Tue 27-12-16	Thu 29-12-16	LC 43
45	Esquema do Sistema Hidráulico máq. L	2 days	Fri 30-12-16	Mon 02-01-17	LC 44
46	Caderno de Estabilidade Intacta	1 day	Wed 14-12-16	Wed 14-12-16	ML 40
47	Caderno de Estabilidade em Avaria	1 day	Thu 15-12-16	Thu 15-12-16	ML 46
48	Caderno de Carenas direitas	1 day	Fri 16-12-16	Fri 16-12-16	ML 47
49	Caderno de Carenas inclinadas	1 day	Mon 19-12-16	Mon 19-12-16	ML 48
50	Cálculo do bordo livre	1 day	Tue 20-12-16	Tue 20-12-16	ML 49
51	Caracteristicas geométricas dos tanque	1 day	Wed 21-12-16	Wed 21-12-16	ML 50
52	Cálculos de arqueação	2 days	Thu 22-12-16	Fri 23-12-16	ML 51

Coastal Catamaran Design



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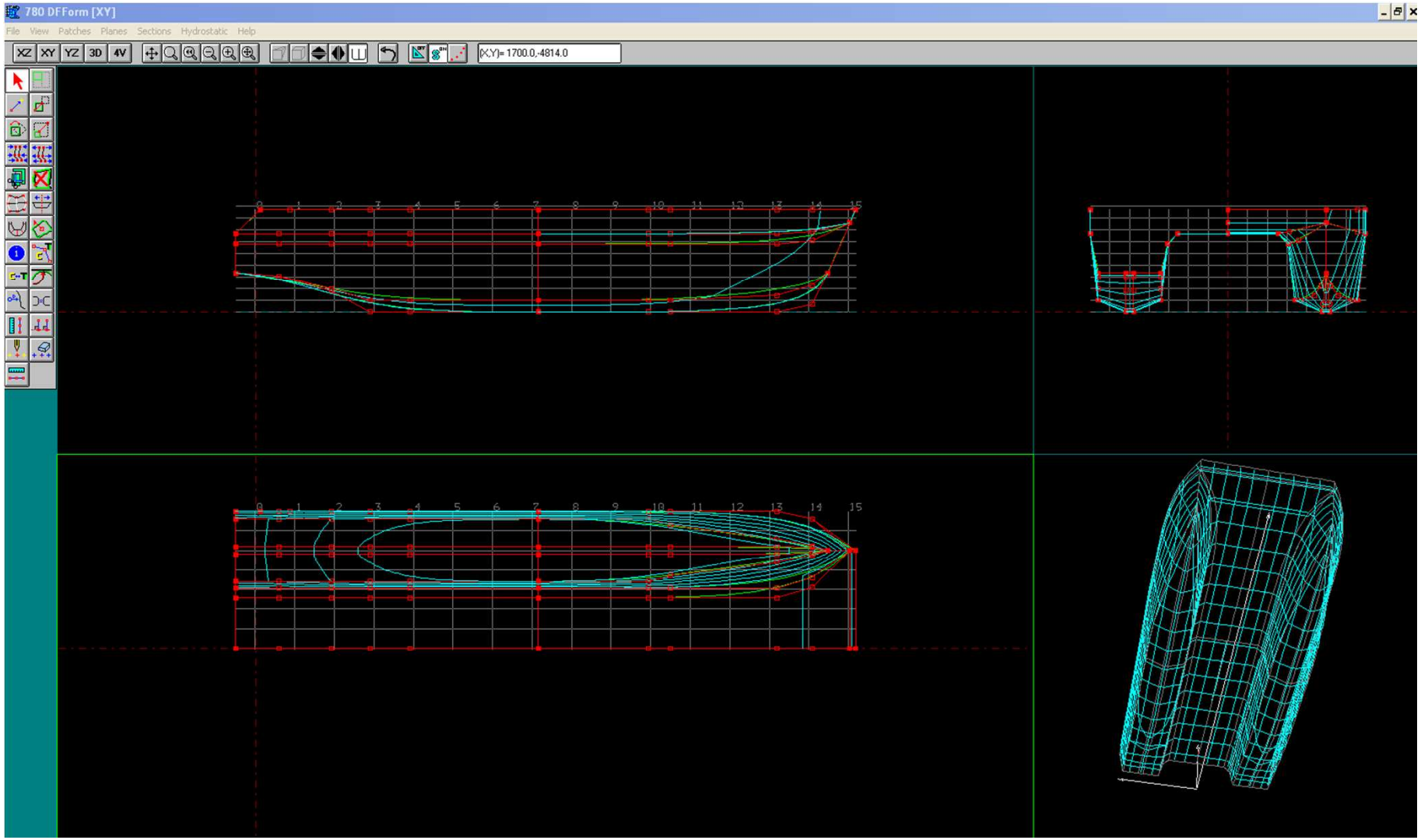
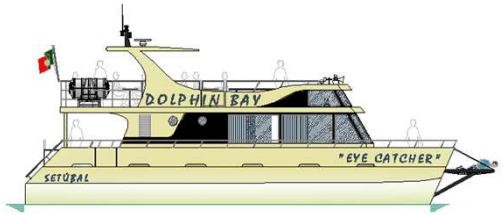
Hull Shape Design



Coastal Catamaran Design



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Hull Shape Design

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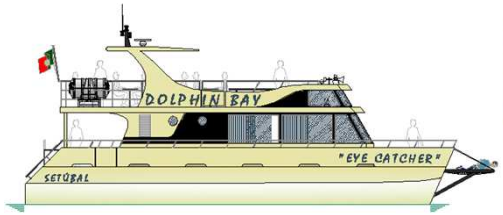

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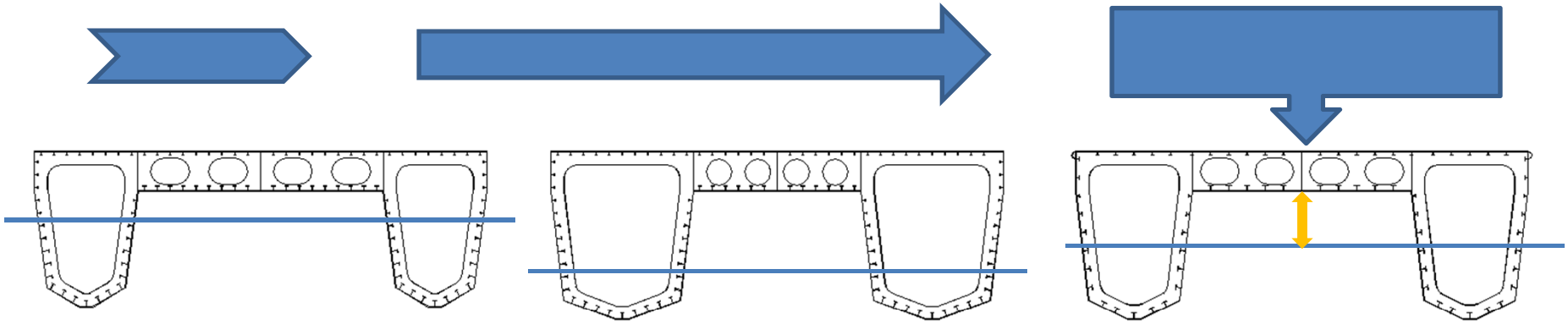
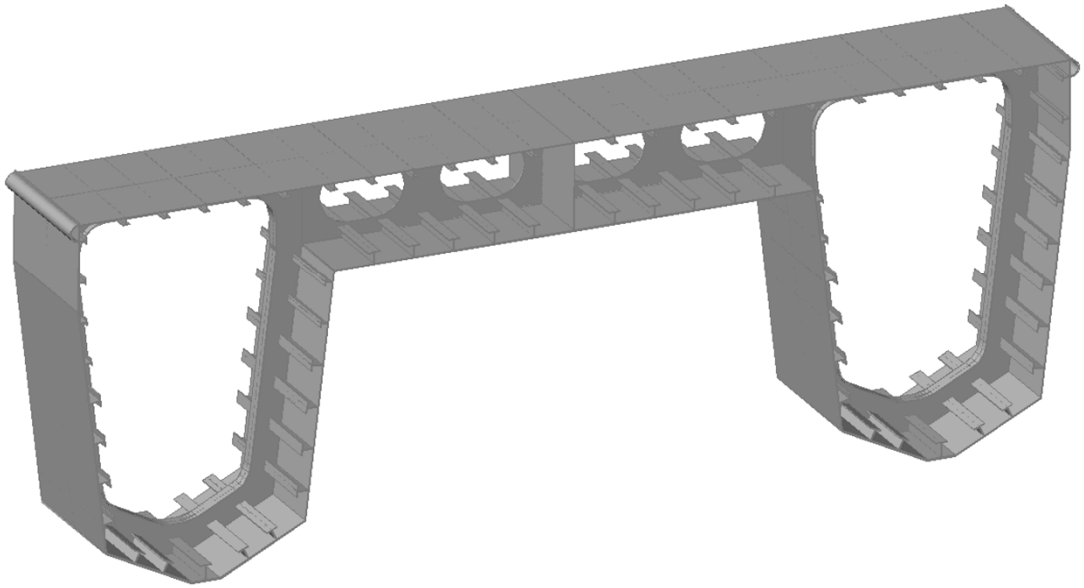
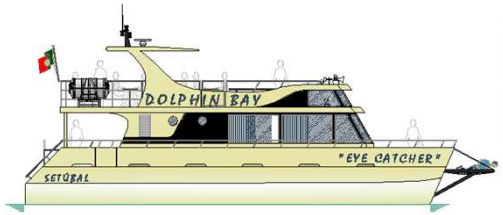
Midship Section Concepts





Coastal Catamaran Design



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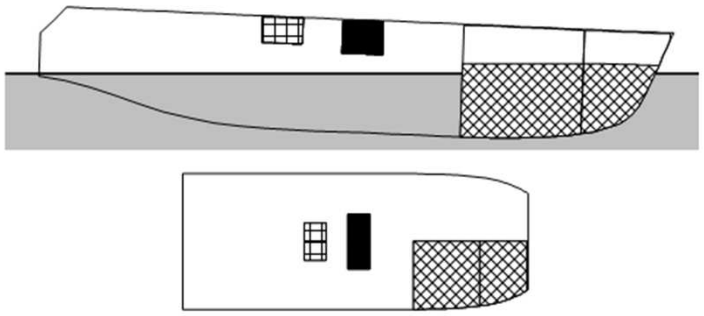
Stability Calculations

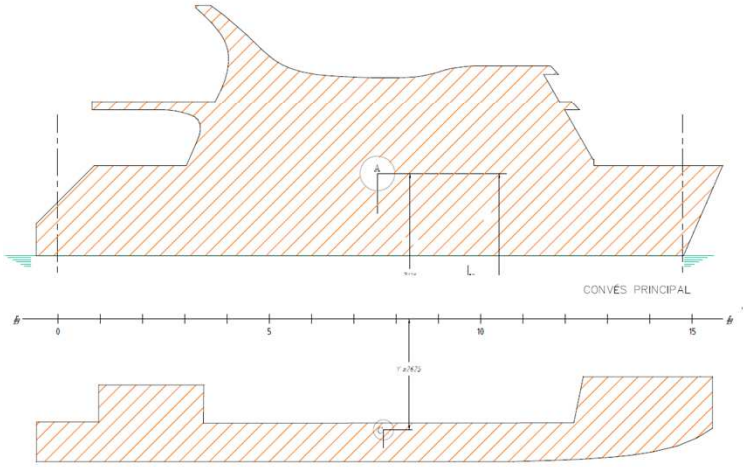
OCEAN engenharia e arquitectura naval Lda — Catamaran 16m – "Setúbal"

5.1.4 Alagamento do Paiol de Vante+Paiol da Amarra



Fluid Legend

Fluid Name	Legend	Weight (MT)	Load%
DIESEL OIL		1.44	94.97%
FRESH WATER		1.12	94.97%
SALT WATER		7.32	5.06%



OCEAN engenharia e arquitectura naval Lda — Catamaran 16m – "Setúbal"

45.00s	17.04f	-1.417	0.773	0.626	0.917 (2)	
50.00s	18.66f	-1.762	0.609	0.686	0.834 (2)	
55.00s	20.09f	-2.087	0.441	0.732	0.745 (2)	
60.00s	21.30f	-2.386	0.274	0.763	0.650 (2)	
65.00s	22.31f	-2.659	0.110	0.780	0.550 (2)	
68.39s	22.87f	-2.829	0.000	0.783	0.479 (2)	RaZero

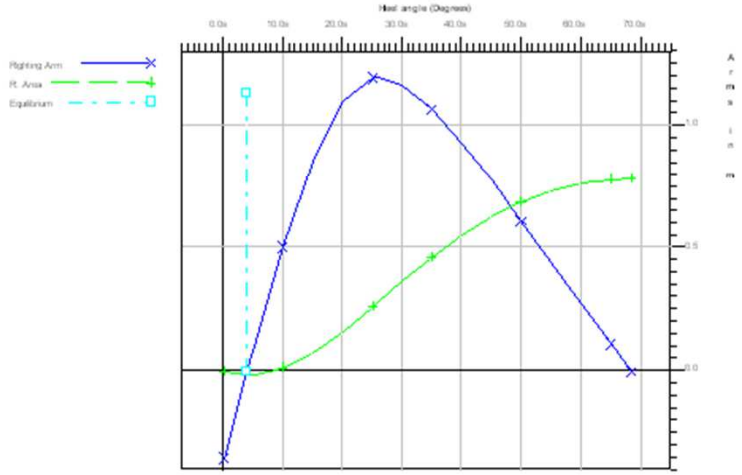
Unprotected Flood Points

Name	L,T,V (m)	Height (m)
(1) VENTILAÇÃO CM EB	3.550f, 2.400p, 3.200	1.969
(2) VENTILAÇÃO CM BB	3.550f, 2.400s, 3.200	1.811

HSC PARTE B, 2.13 E ANEXO 7, 2.1, 2.2, 2.6.E.3.2.2

Limit	Min/Max	Actual	Margin	Pass
(1) Absolute Angle at Equilibrium	<10.00 deg	3.83	6.17	Yes
(2) Area from Equilibrium to 15.00 deg or Flood	>0.0280 m-R	0.087	0.059	Yes
(3) Righting Arm at MaxRA	>0.050 m	1.192	1.142	Yes
(4) Angle from Equilibrium to Flood	>7.00 deg	64.57	57.57	Yes
(5) Absolute Angle at Equilibrium	<15.00 deg	3.83	11.17	Yes

Righting Arms vs. Heel



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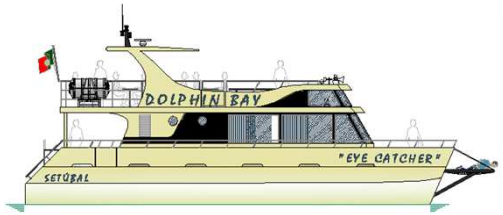

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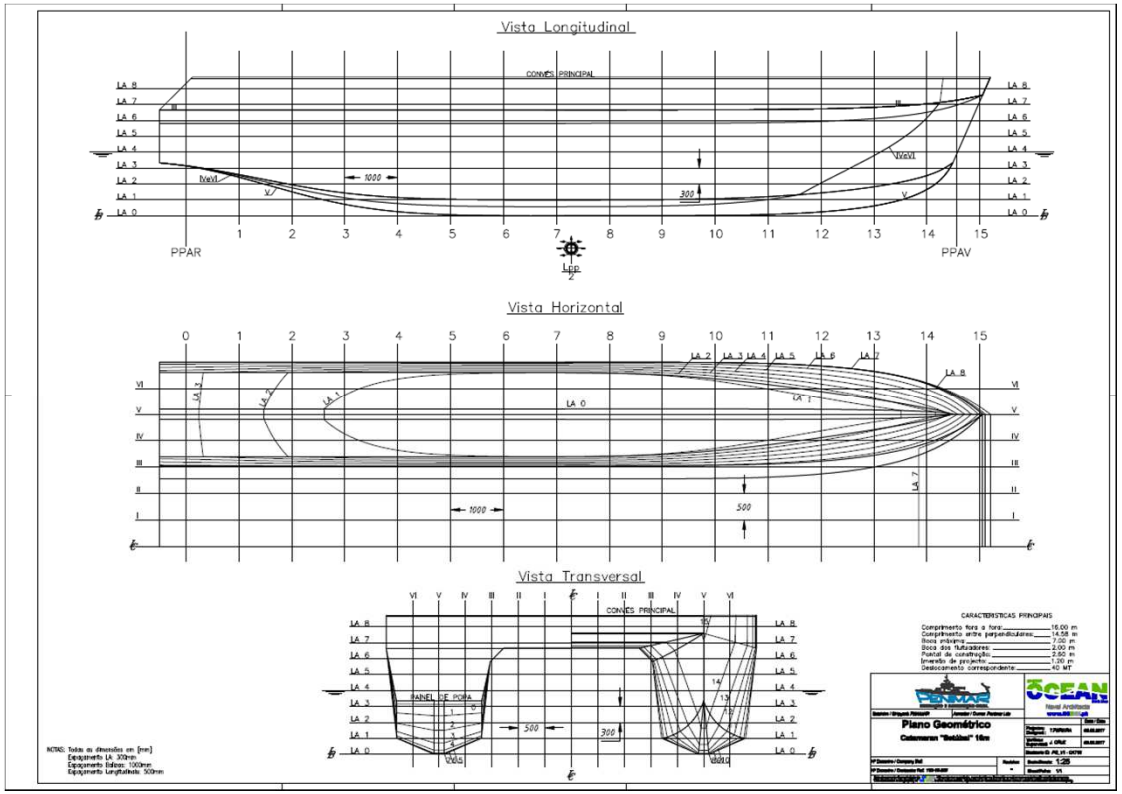
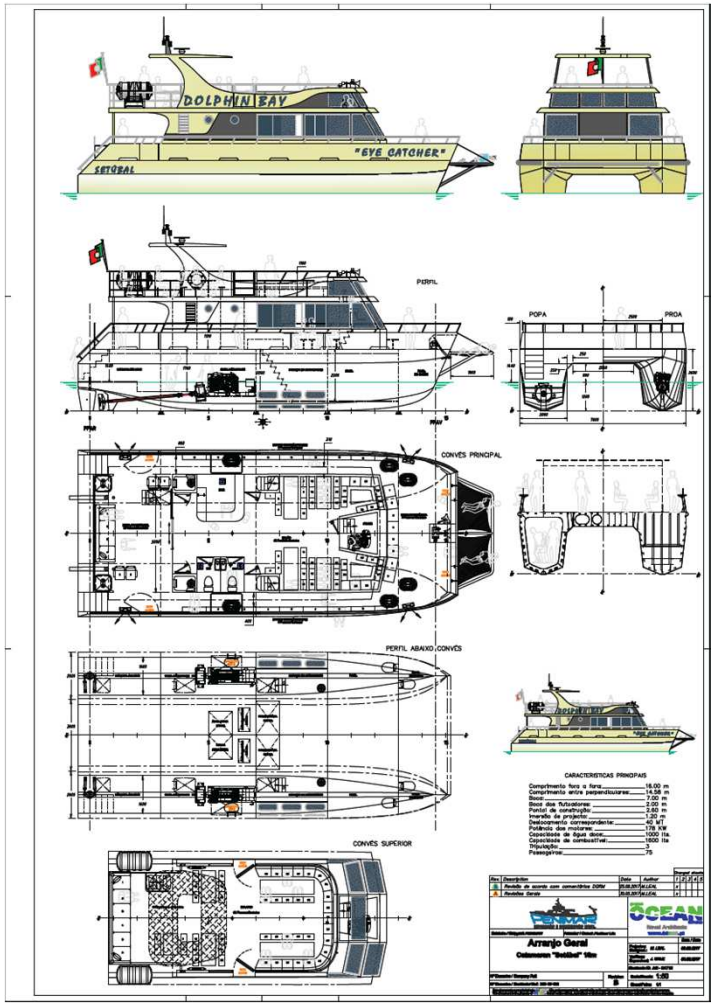
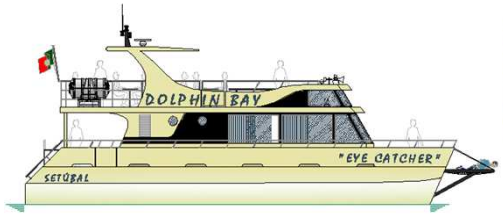
Lines Plan



General Arrangement





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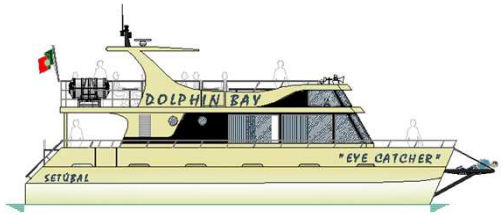
2nd Stage – Engineering

- CLASSIFICATION SOCIETY RULES (BV);
- FLAG AUTHORITIES CRITERIA (DGRM);
- STRENGHT DESIGN AND CALCULATION;
- MIDSHIP DESIGN;
- STRUCTURAL PLANS FOR APPROVAL;
- BASIC PROJECT PLANS;
- PRELIMINARY STABILITY BOOKLETS;
- SYSTEMS, PIPING AND ELECTRICITY DIAGRAMS;

Coastal Catamaran Design



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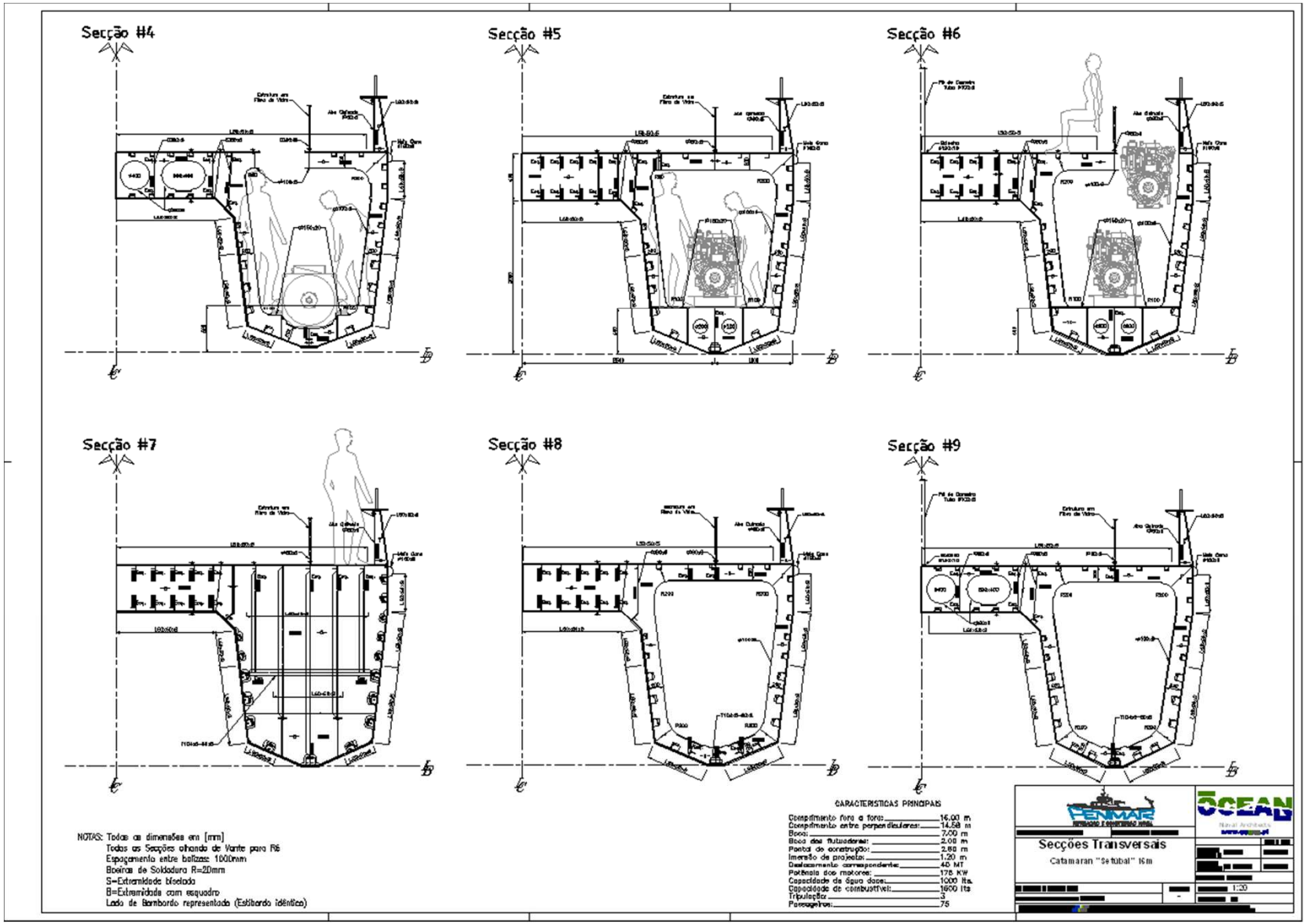
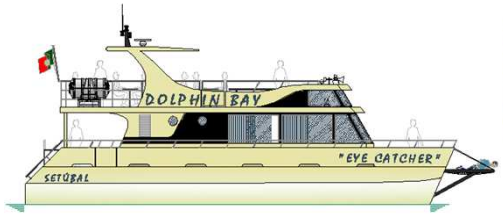
Typical Section Concepts



Coastal Catamaran Design



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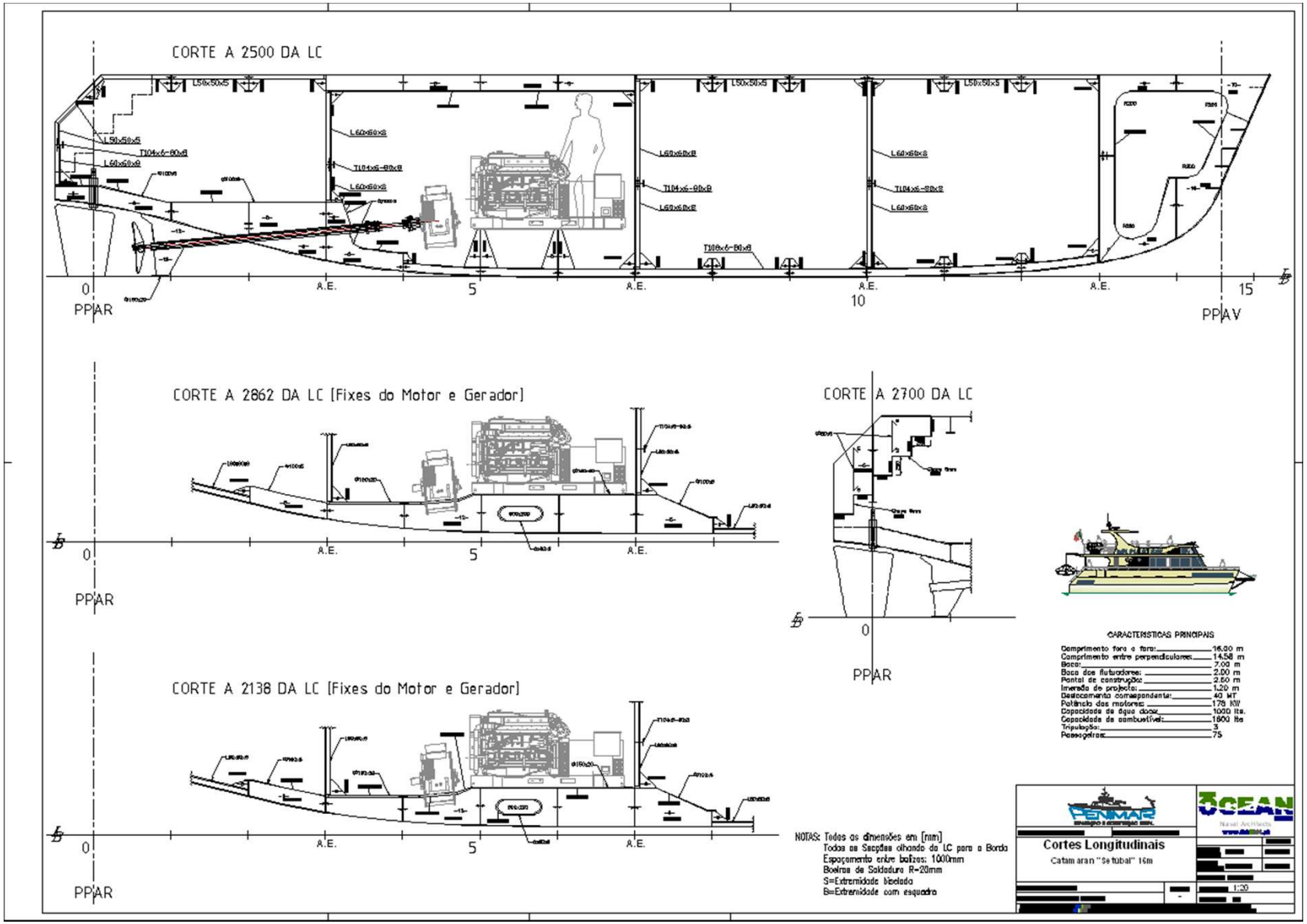
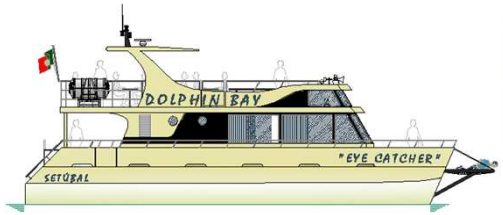
Longitudinal Section Concepts



Coastal Catamaran Design



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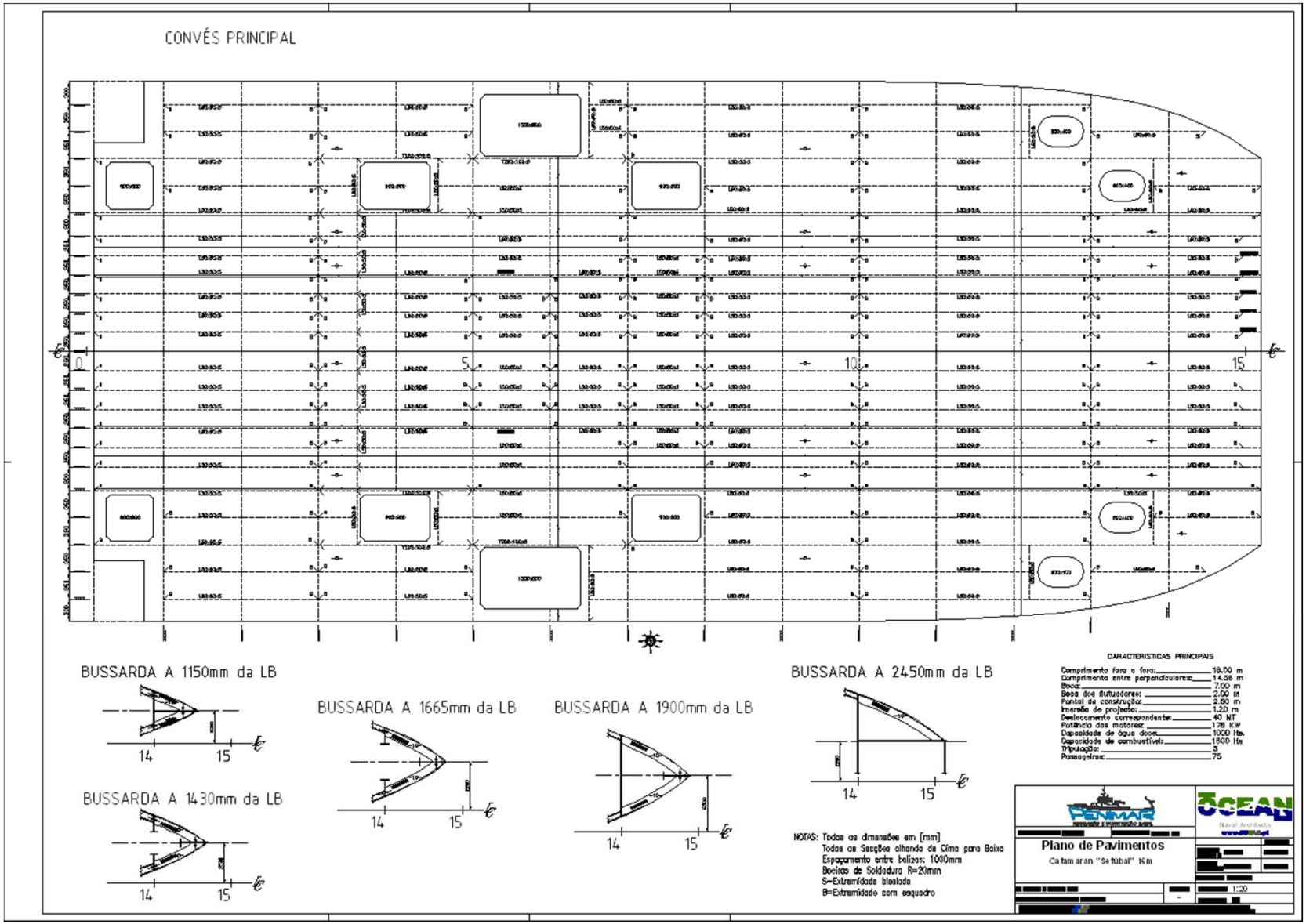
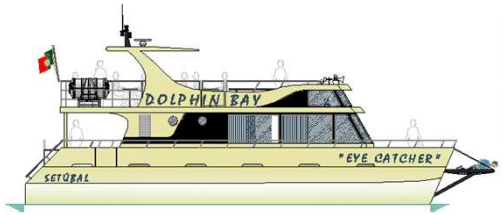
Main Deck Concepts



Coastal Catamaran Design



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RFGP Superstructure Concepts

SECÇÕES DE RÉ
Anteparo Ré
Secção #05
CONVÉS

SECÇÕES TIPICAS
Secção #09
Secção #10
CONVÉS

SECÇÃO DE VANTE
CONVÉS

CONVÉS SUPERIOR

ANTEPARA LATERAL
CONVÉS

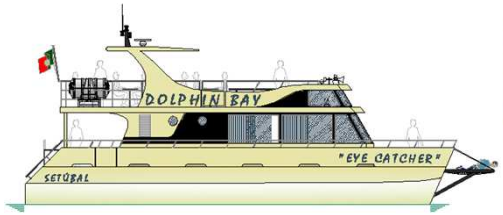
DETALHE DOS LAMINADOS TÍPICOS
(ESCALA 1:5)
Core (Structural Foam)
Light Weight Filler

CARACTERÍSTICAS PRINCIPAIS
Comprimento fora a fora: 16.00 m
Comprimento entre perpendiculares: 14.58 m
Boca: 7.00 m
Boca dos flutuadores: 2.00 m
Pontal de construção: 2.80 m
Imersão de projecto: 1.20 m
Deslocamento correspondente: 40 MT
Potência dos motores: 178 KW
Capacidade de água doce: 1000 lts.
Capacidade de combustível: 1600 lts
Tripulação: 3
Passageiros: 75

DETALHE A
DETALHE B
DETALHE C

Superstrutura
Catamaran "Setúbal" 16m

Coastal Catamaran Design



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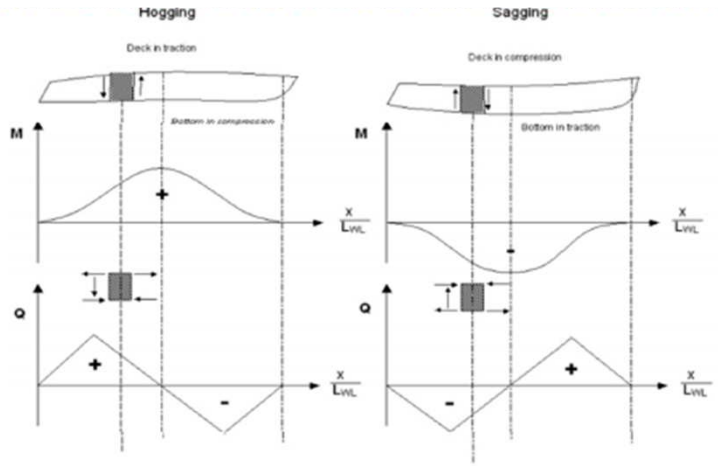
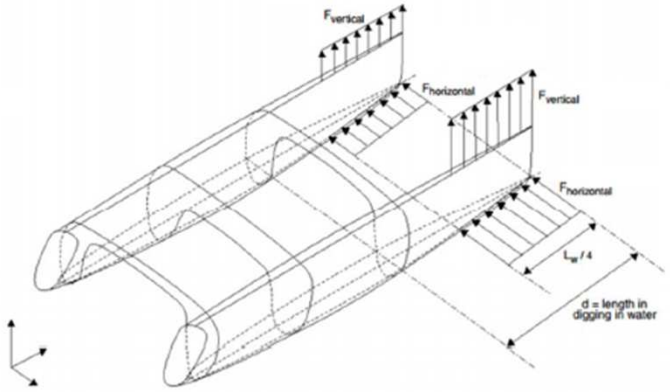
Class Rules

2. Carregamentos Estruturais do Casco





2.1 Still Water Loads

2.1.1 Longitudinal Bending Moments

$M_{SW,H}$	104.16	kN.m

2.1.2 Shear Forces

Q_{SW}	21.45	kN

Type of yachts	M_{sw}	Q_{sw}
Conventional motor yachts (1)	$M_{SW,H} = 0,8\ M_{WV}$	$Q_{SW} = 0,8\ Q_{WV}$
Motor yachts with large transom (1)	$M_{SW,H} = 0,4\ M_{WV}$	$Q_{SW} = 0,4\ Q_{WV}$
Catamaran motor yacht (1)	$M_{SW,H} = 0,8\ M_{WV}$	$Q_{SW} = 0,8\ Q_{WV}$
Monohull sailing yacht (2)	$M_{SW,S} = 0,2\ M_{WV}$	$Q_{SW} = 0,2\ Q_{WV}$
Catamaran sailing yacht (1)	$M_{SW,H} = 0,8\ M_{WV}$	$Q_{SW} = 0,8\ Q_{WV}$

(1) Still water bending moment are always considered in hogging condition, resulting in tensile stress in the deck
(2) Still water bending moment are always considered in sagging condition, resulting in compression stress in the deck

2.2 Wave Loads

2.2.1 Head Sea Condition

L_W	15.54	m		
C_W	2.50	m	1.09	m
B_W	1.82	m		

$C_W = 0,625\ (118 - 0,36\ L_W)\ L_W 10^{-3}$

M_{WV}	130.20	kN.m
Q_{WV}	26.81	kN

2.4 Combinação Global das Forças

2.4.1 Bending Moment

Situation	M (kN.m)
Hogging	234.35
Sagging	-416.63
Quartering seas	520.78
Digging in wave	0

BV Rules for Shipbuilding

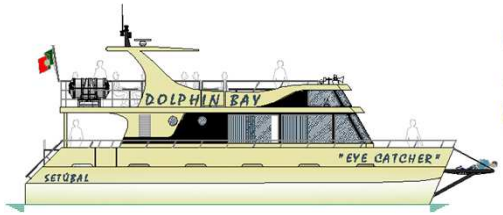
Bending moments (kN.m)	Monohull		Catamarans	
Situation	Motor	Sailing	Motor	Sailing
Hogging	$M_{SW} + M_{WV}$	$M_{SW} + M_{WV}$	$M_{SW} + M_{WV}$	$M_{SW} + M_{WV}$
Sagging	$M_{SW} - M_{WV}$	$M_{SW} - M_{WV} - 0,7\ M_{RIG}$	$M_{SW} - M_{WT}$	$M_{SW} - M_{WV} - 0,7\ M_{RIGT}$
Quartering seas	–	–	M_{WT}	$M_{WT} + 0,7\ M_{RIGT}$
Digging in wave	–	–	M_I	$M_I + 0,7\ M_{RIGT}$

2.4.2 Vertical shear force

Situation	Q (kN)
Hogging	48.26
Sagging	-5.36
Quartering seas	53.62
Digging in wave	0

Vertical shear force (kN)	Monohull		Catamarans	
Situation	Motor	Sailing	Motor	Sailing
Hogging	$Q_{SW} + Q_{WV}$	$Q_{SW} + Q_{WV}$	$Q_{SW} + Q_{WV}$	$Q_{SW} + Q_{WV}$
Sagging	$Q_{SW} - Q_{WV}$	$Q_{SW} - Q_{WV} - 0,7\ Q_{RIG}$	$Q_{SW} - Q_{WV}$	$Q_{SW} - Q_{WV} - 0,7\ Q_{RIGT}$
Quartering seas	–	–	Q_{WT}	$Q_{WT} + 0,7\ Q_{RIGT}$
Digging in wave	–	–	Q_I	$Q_I + 0,7\ Q_{RIGT}$

Coastal Catamaran Design



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Class Rules

3. Pressões

3.1 Fundo e Costado

3.1.1 Waves Loads

B_i	3.18	m
L_{WD}	2.40	m
P_{dmin}	7.00	KN/m^2
C_W	2.51	m
h_2	0.00	m
h_2	1.01	m
X_i	1.40	-

- $C_W = 10 \log (L_W) - 10$ for $L_W \geq 18$ m
- $C_W = 0{,}065\ L_W + 1{,}5$ for $L_W < 18$ m

bottom and external side shell of hull
Internal side shell and bottom cross deck
área corresponde a uma secção da proa

Figure 1 : Vertical distance z

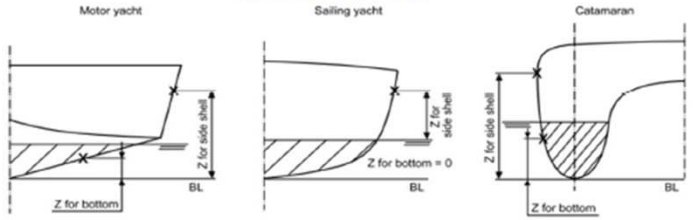
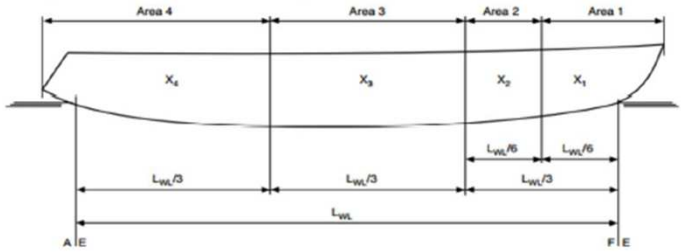


Figure 2 : Load areas and coefficient X_i for the external side shell and bottom sea pressure



Type of yachts	Area 4 X_4	Area 3 X_3	Area 2 X_2	Area 1 X_1
Monohull motor yacht	2,8	2,2	1,9	1,7
Monohull sailing yacht	2,2	1,9	1,7	1,4
Multihull motor yacht	2,8	2,2	1,9	1,4
Multihull sailing yacht	2,5	2,2	1,7	1,2

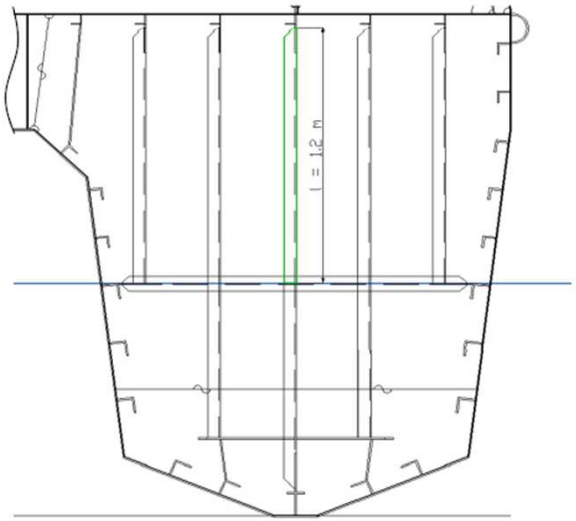
6.7.2 Scantlings

6.7.2.1 Perfil L(60x60x8)

s	0.35	m		
l	1.2	m		
Coeff	0.85	-	≥	0
Coeft	0.85	-		
σ	72.45	N/mm^2		
τ	46.575	N/mm^2		
p_{supper}	6.22	kN/m^2		
p_{slower}	23.46	kN/m^2		

Z	6.84	cm^3
A_{sh}	0.70	cm^2

Z	6.88	cm^3
A_{sh}	2.50	cm^2



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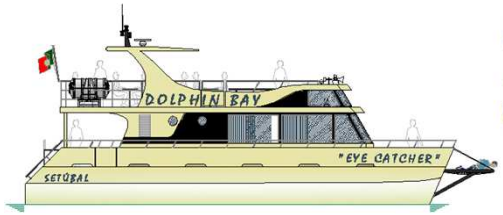

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Weight Calculations

Controlo de Pesos

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Catamaran 16m

PENIMAR
REPARAÇÃO E CONSTRUÇÃO NAVAL

RESUMO

CONDIÇÃO DESLOCAMENTO MÁXIMO

PESOS	Peso [Ton]	x [m]	y [m]	z [m]
Casco - Alumínio	10.00	7.50	0.00	1.56
Forro	0.00	0.00	0.00	0.00
Ponte e casario - Fibra	3.00	8.00	0.00	4.00
Aprestamento	14.25	5.03	0.05	2.29
Outros (margem incertezas)	3.80	7.00	0.00	1.56
Águas Negras	0.00	0.00	0.00	0.00
Água Doce	1.00	9.50	0.00	2.20
Combustíveis	2.00	11.50	0.00	2.20
Tripulação e Mantimentos	5.95	7.00	0.00	3.60
Totais	40.00	6.79	0.02	2.35

XG NAVIO =	6.79 m
peso de casco:	13.00 T
navio leve:	31.05 T
porte:	8.95 T

CONDIÇÃO NAVIO LEVE

PESOS	Peso [Ton]	x [m]	y [m]	z [m]
Casco - aço (modelo)	10.00	7.50	0.00	1.56
Forro (modelo)	0.00	0.00	0.00	0.00
Casco acima cp •ponte (modelo) - ALUMíNIO	3.00	8.00	0.00	4.00
Aprestamento	14.25	5.03	0.05	2.29
Outros (margem incertezas)	3.80	7.00	0.00	1.56
Totais	31.05	6.36	0.02	2.13

Equipamento de Máquinas

Elemento	Peso [Kg]	x [mm]	y [mm]	z [mm]	Notas
gerador 4045DFM70	2200	6000	0	900	dados penimar
motor elétrico (x2)	1080	4700	0	500	dados penimar
gerador de emergência					estimado
quadro eléctrico principal (ponte)	150	11200	400	4700	dados penimar
quadros eléctricos de corte (CM)	100	5500	0	5600	dados penimar
baterias de arranque	128	1500	0	1200	dados penimar
baterias de serviço e emergência (ponte)	260	11700	750	3800	dados penimar
baterias de radio	48	11400	-750	5650	dados penimar
piping	2000	5800	0	1600	estimado
bomba combustível	20	5000	0	1500	estimado
bomba de esgoto	36	4000	0	1500	estimado
bomba de incêndio	20	5500	0	1500	estimado
bomba hidráulica (?)					
ventiladores (2)	30	5250	0	3200	estimado
máquina do leme (x2)	200	0	0	1300	estimado
equipamento de navegação	20	11300	0	6600	estimado
Molinete de proa	120	14500	0	2800	estimado
TOTAIS	6412	5983.27	34.15	1455.99	
	Peso [Kg]	x [mm]	y [mm]	z [mm]	

Aprestamento Casco

Elemento	Peso [Kg]	x [mm]	y [mm]	z [mm]	Notas
2 ferros tipo HALL	120	15000	0	2400	estimado
4 cabeços amarração	80	7600	0	2700	estimado
mastro	80	11300	0	6600	estimado
hélice passo fixo 750mm ø	300	600	0	420	estimado
porta do leme	240	0	0	450	estimado
manga da madre do leme	60	0	0	1000	estimado
linha de veios	400	2600	0	550	estimado
manga do veio	80	2100	0	500	estimado
escadas	160	7600	0	2700	estimado
pintura	320	7500	0	2400	estimado
defensas	150	7500	0	2500	estimado
TOTAIS	1990	4744	0	1588	
	Peso [Kg]	x [mm]	y [mm]	z [mm]	

Aprestamento Diverso

Elemento	Peso [Kg]	x [mm]	y [mm]	z [mm]	Notas
Cadeiras e mesas	1444	7000	0	3400	estimado
Mobiliário W.C. + piso	300	4300	-1700	3000	estimado
Aprestamento Ponte + isolamento + tecto	500	11200	0	4200	estimado
Mobiliário bar + isolamento	600	4300	1700	3100	estimado
1 bote + grua	700	-230	0	4100	estimado
balsas	200	1900	0	5300	estimado
isolamento salão	600	7300	0	3700	estimado
janelas/escotilhas/portas	600	8800	0	3600	estimado
isolamentos CM	600	3600	0	1900	estimado
Aprestamento Eléctricos	300	8000	0	3000	estimado
Lastro quilha					
TOTAIS	5844.00	4091	87	3443	
	Peso [Kg]	x [mm]	y [mm]	z [mm]	

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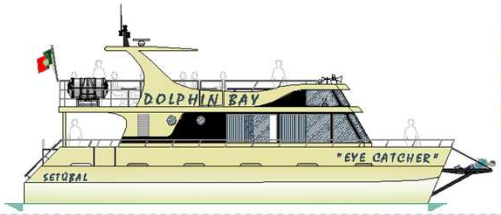

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3D Model

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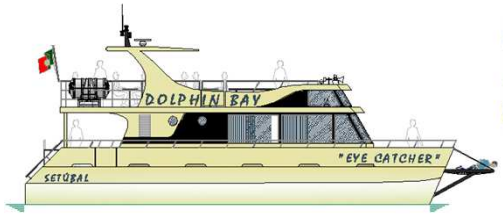

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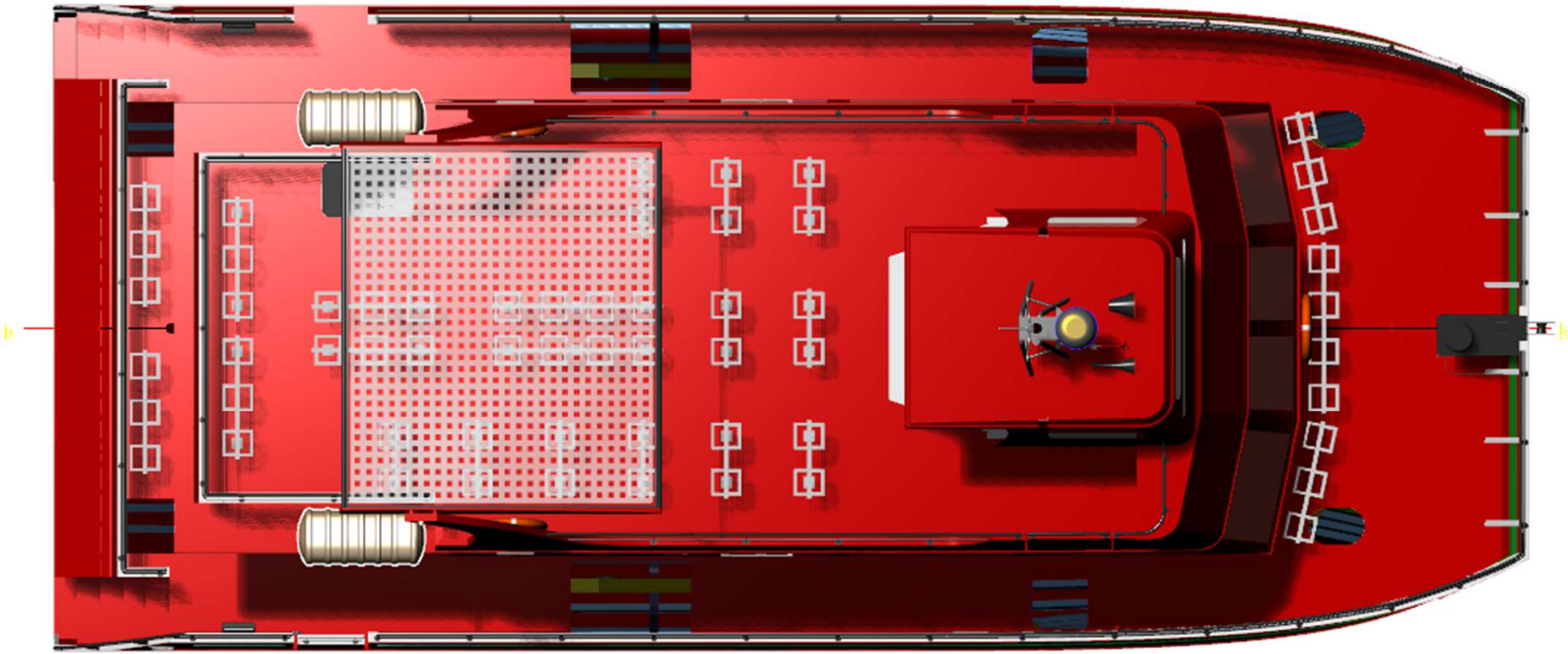

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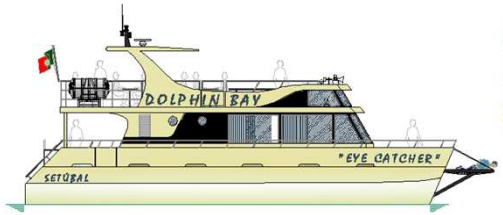

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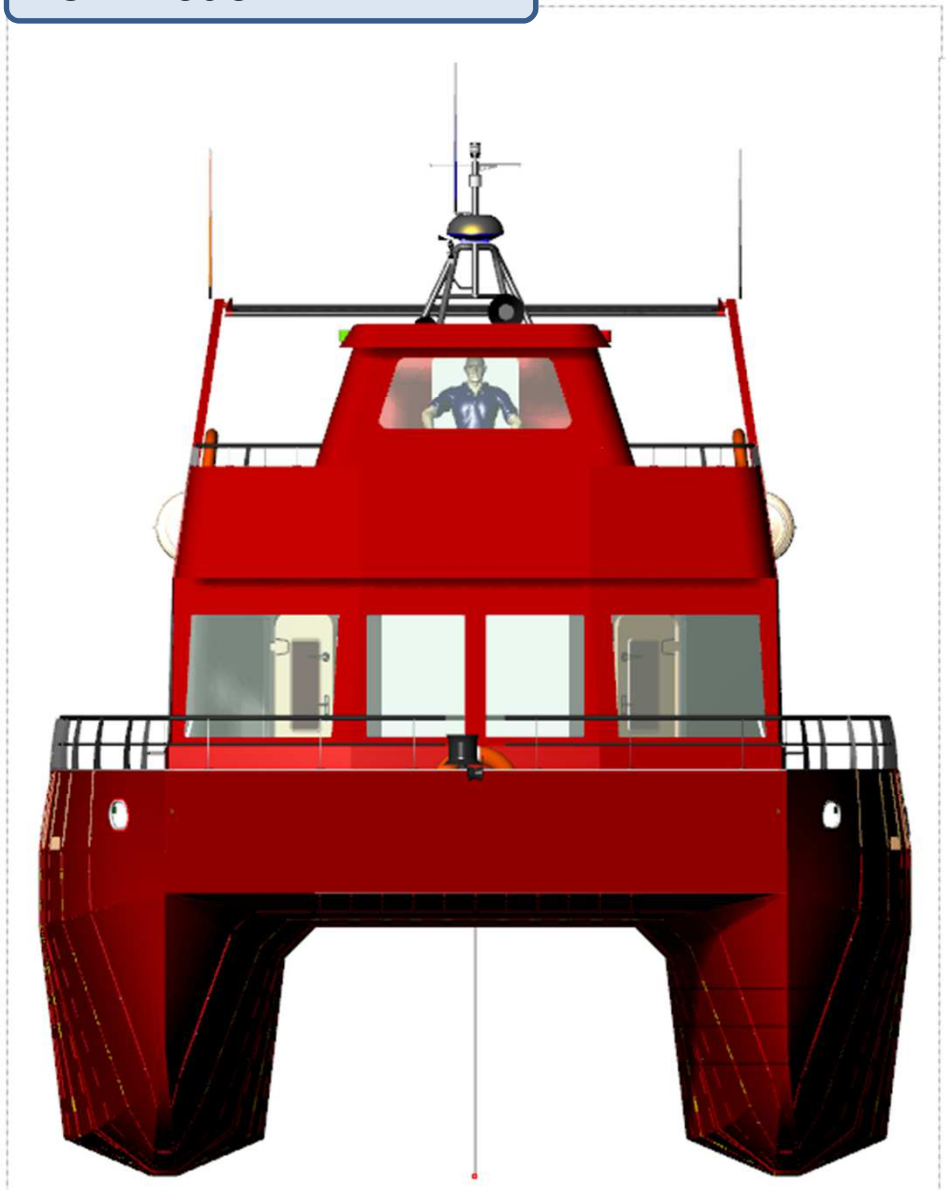

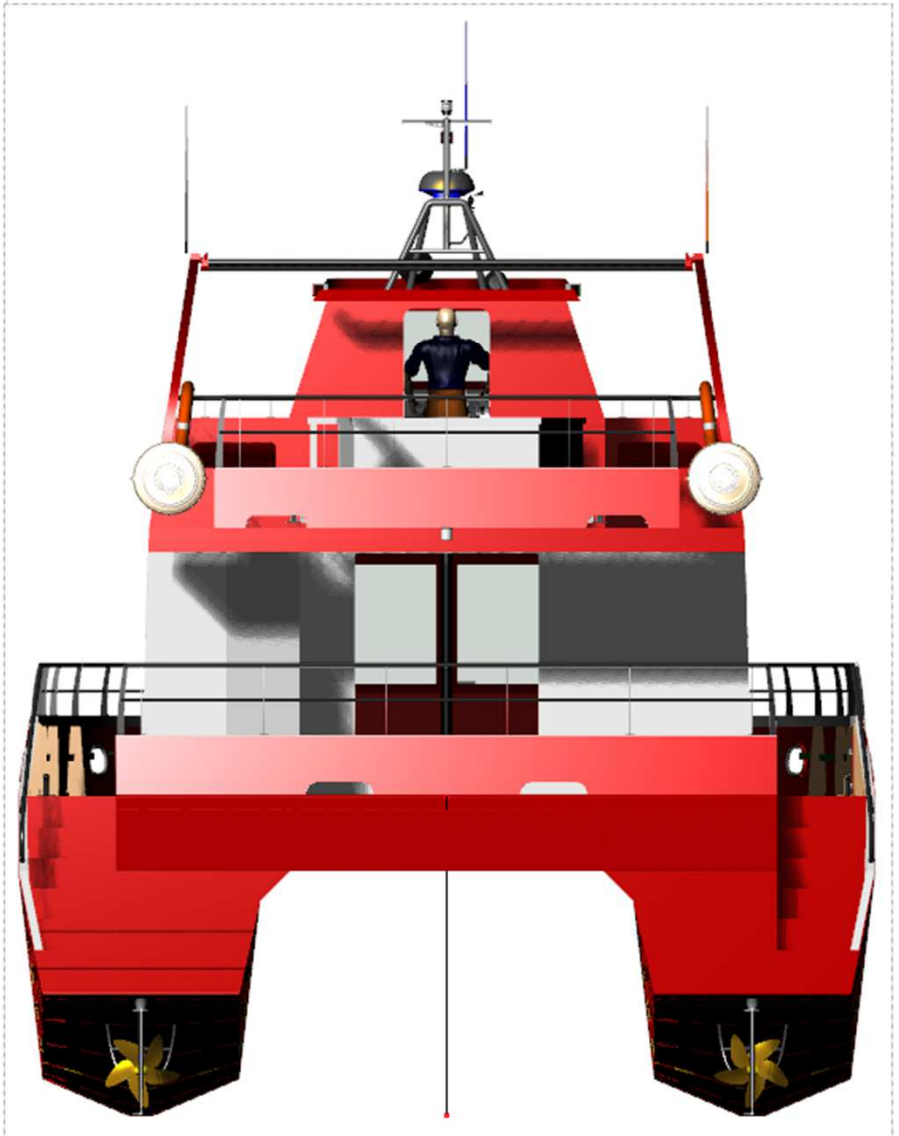

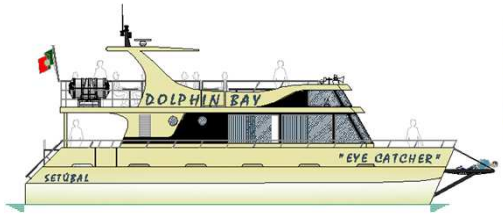

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3rd Stage – Production & Detailed Engineering

- PRODUCTION AND NAMING OF ALL SHIP'S PARTS;
- SHIP'S 3D MODEL FOR VERIFICATIONS
- PARTS NESTING;
- PROFILE CUTTING;
- ASSEMBLY DRAWINGS;
- DETAILED DESIGN;
- PIPING PRODUCTION;
- COORDINATION DRAWINGS;

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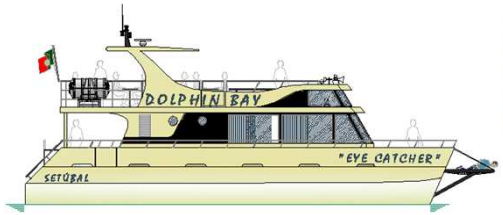

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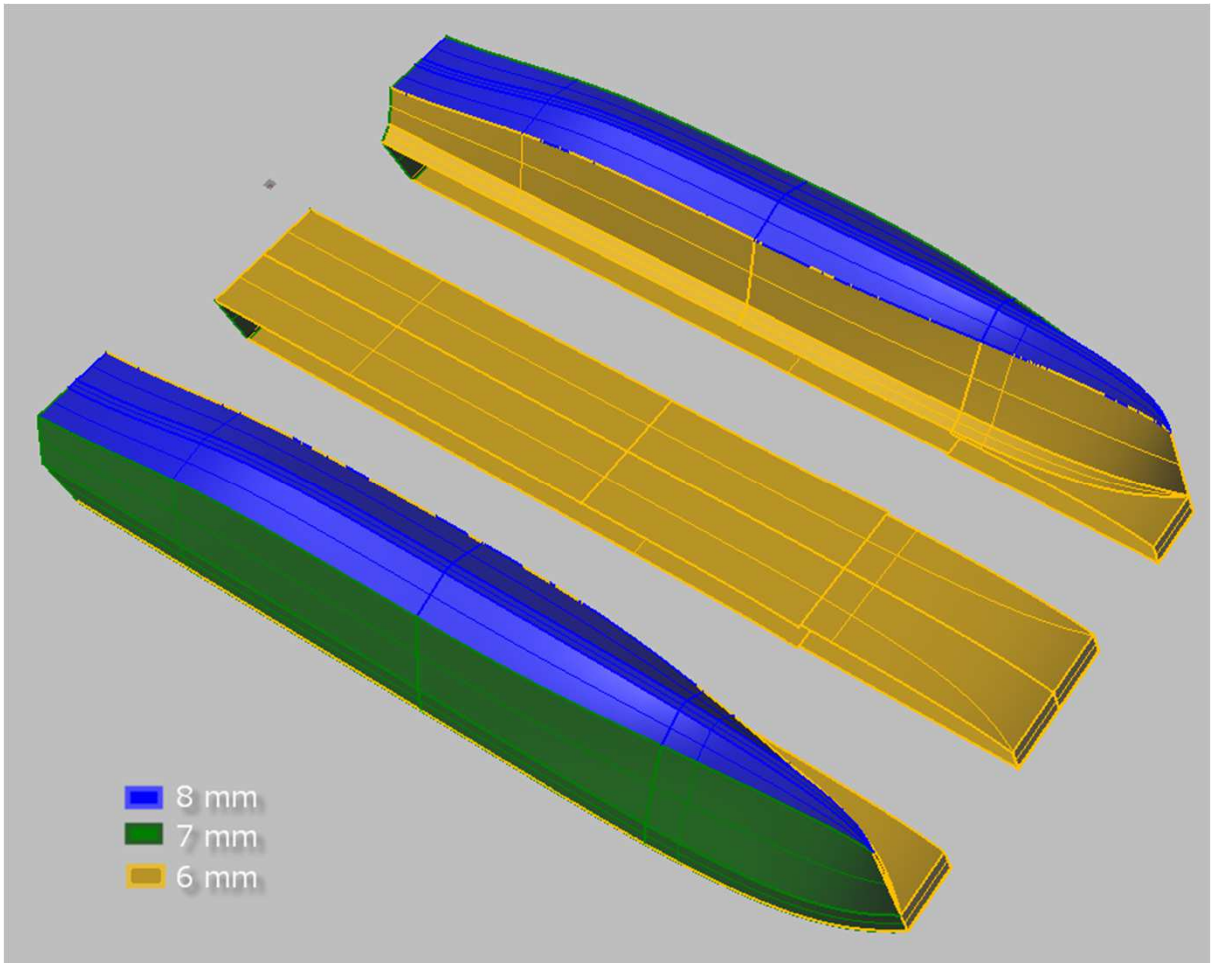
Block Division



THE 16m LENGHT OF THE HULLS
ALLOWED THE FABRICATION OF
3 MODULES ON THE ENTIRE LENGHT

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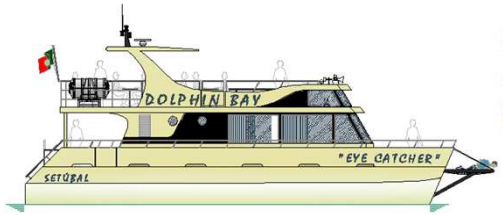

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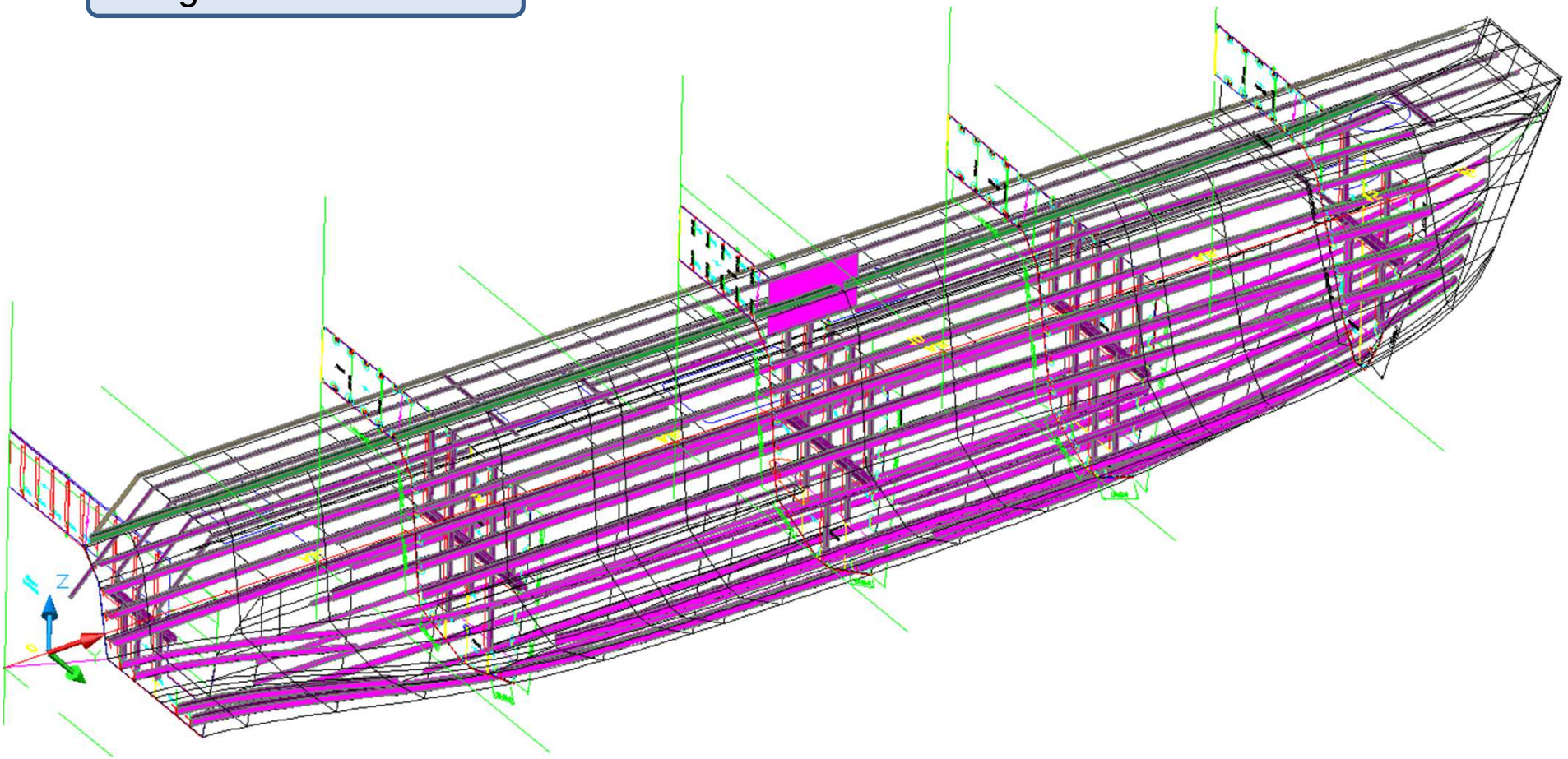
Longitudinal Structure



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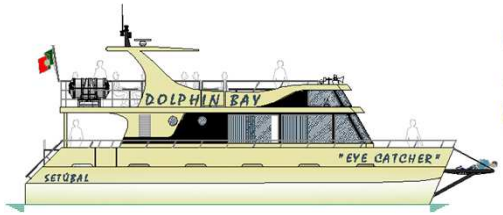

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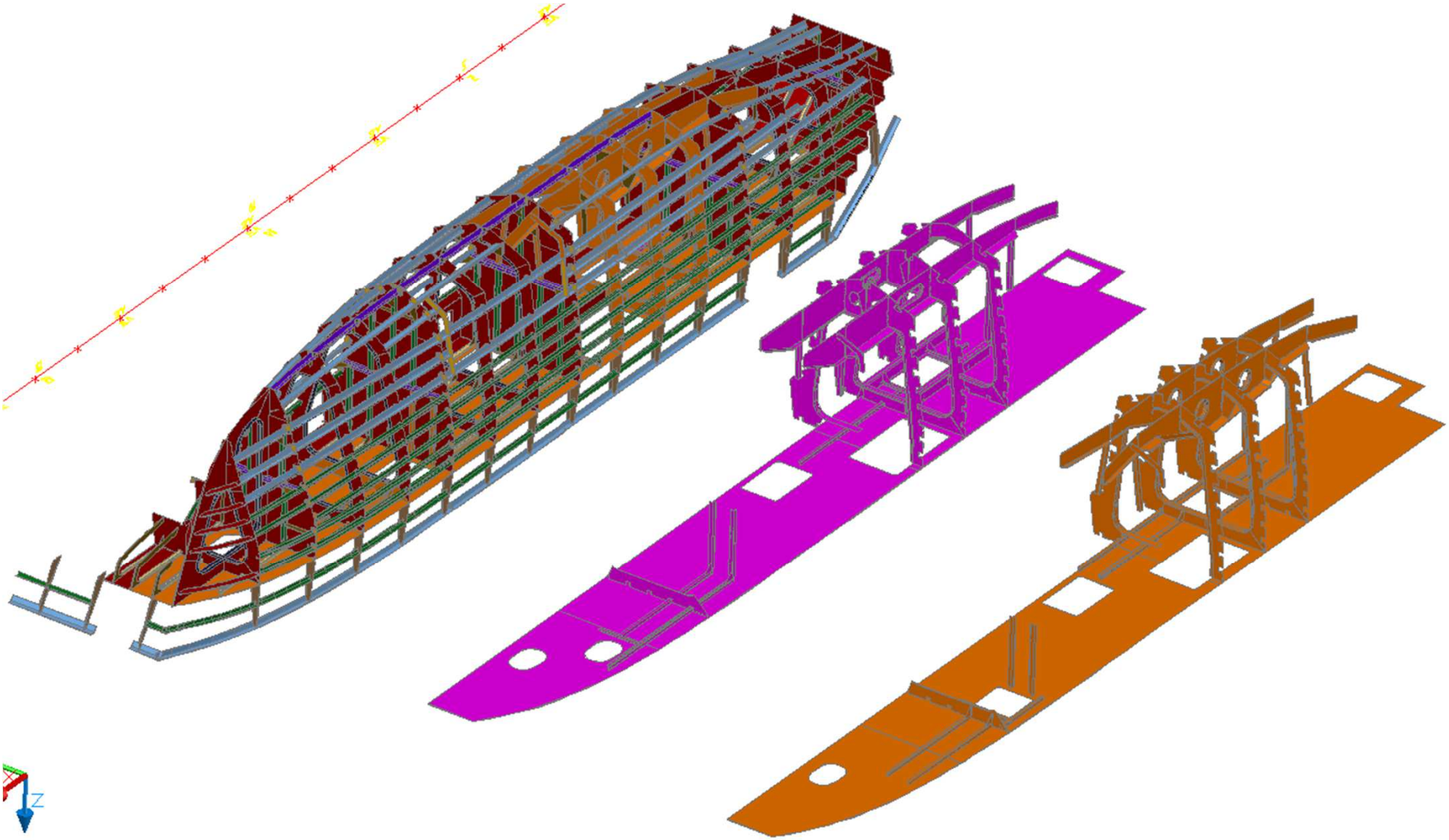
Detailed Assembly



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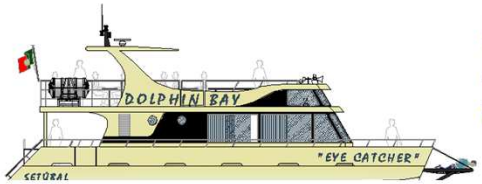

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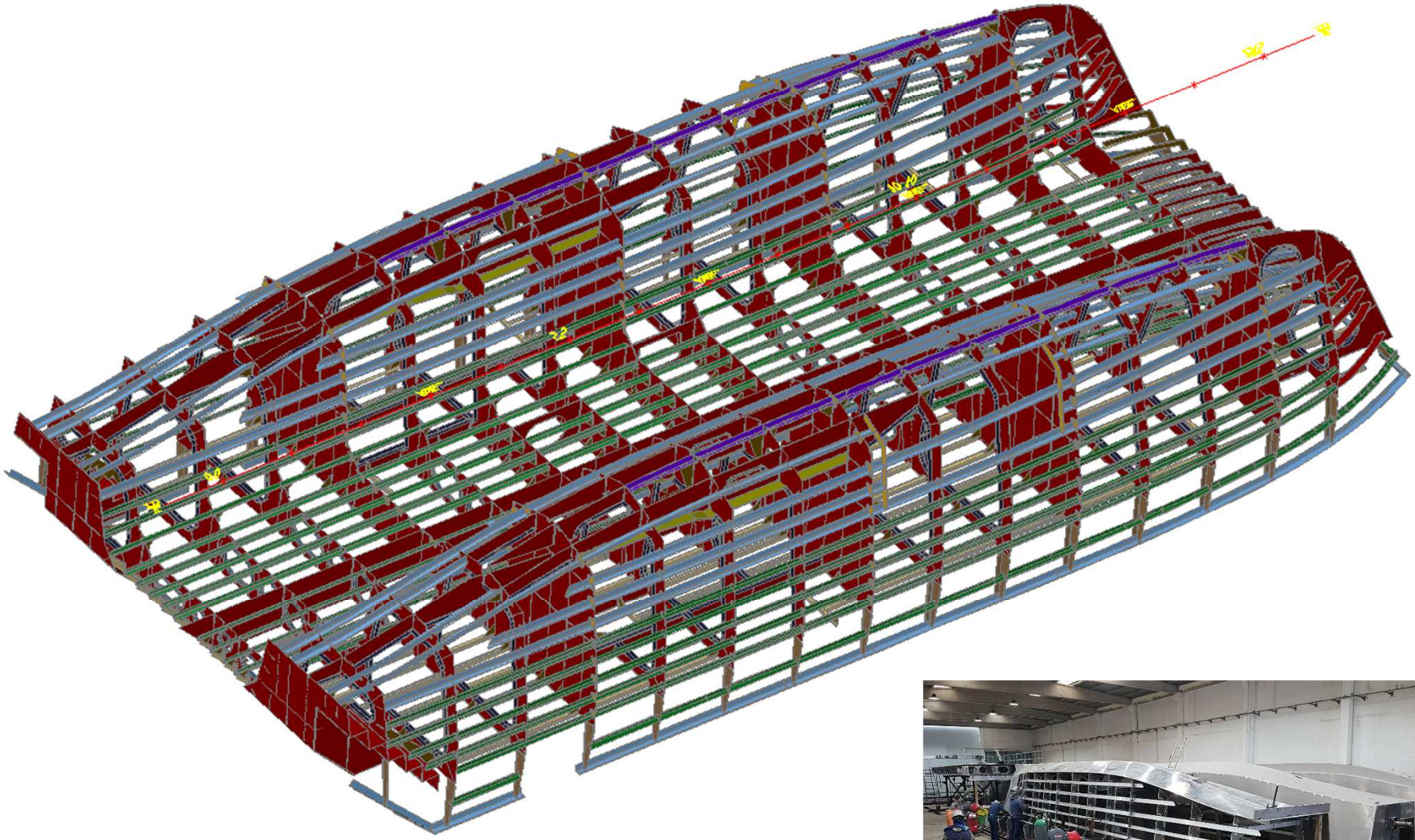

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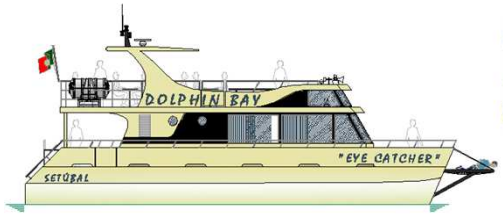

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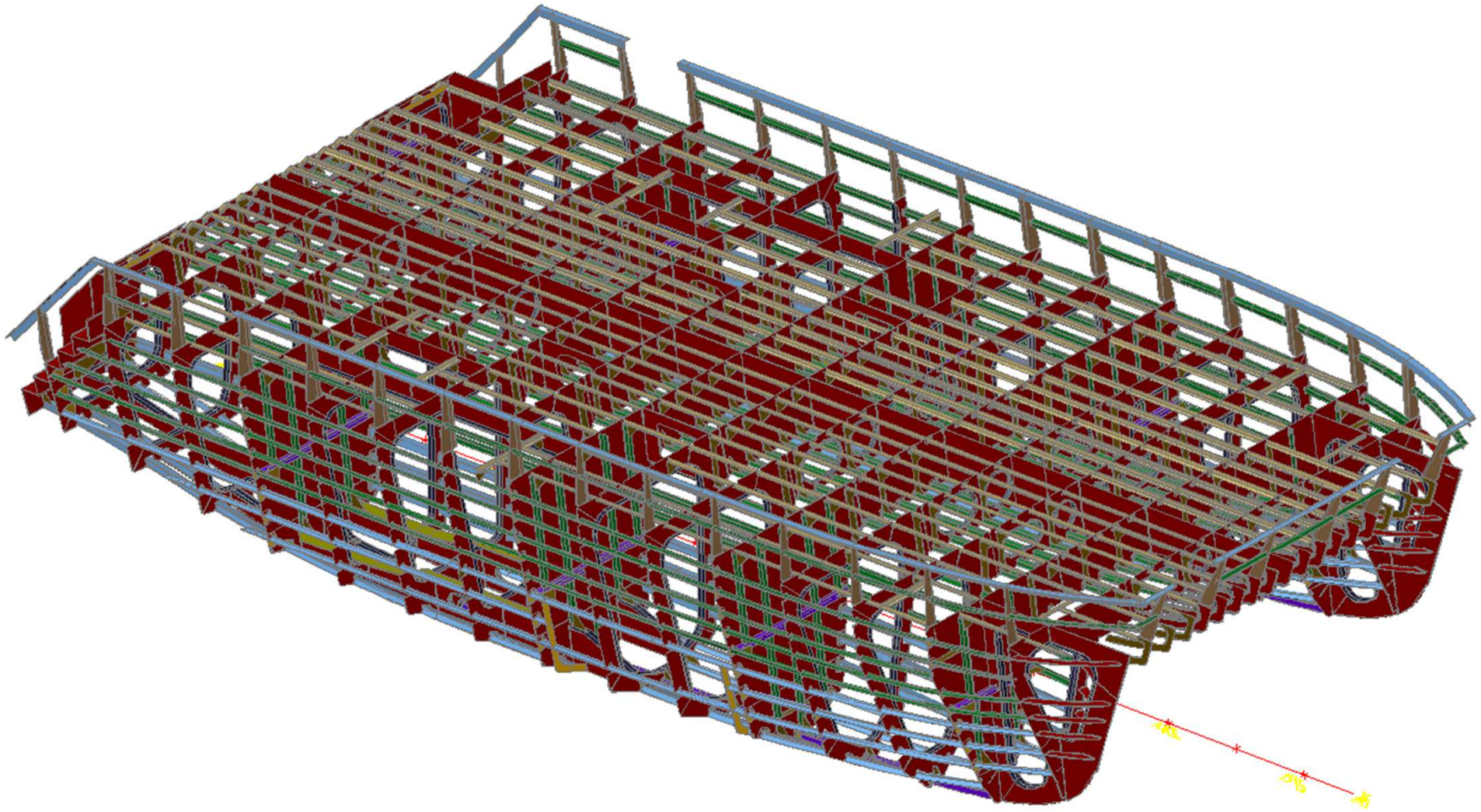

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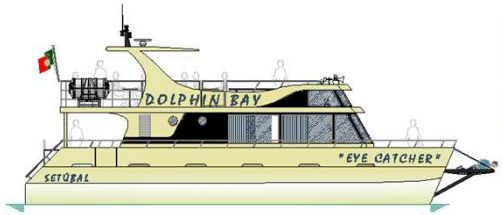

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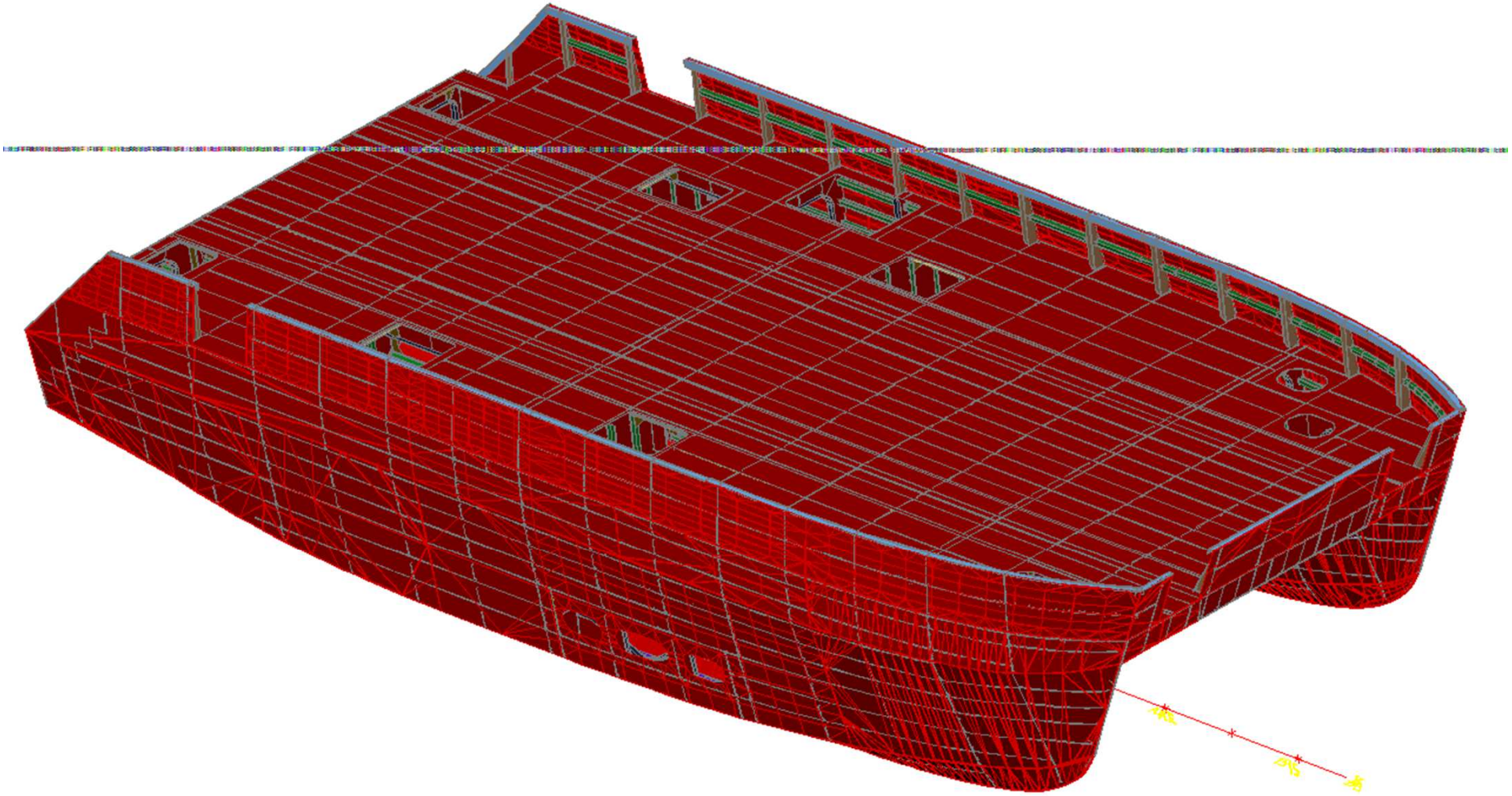
Design Calculations



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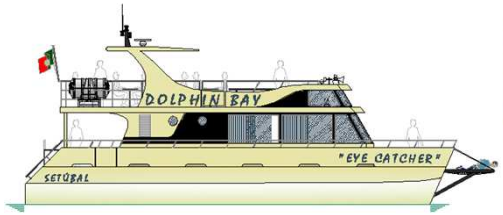

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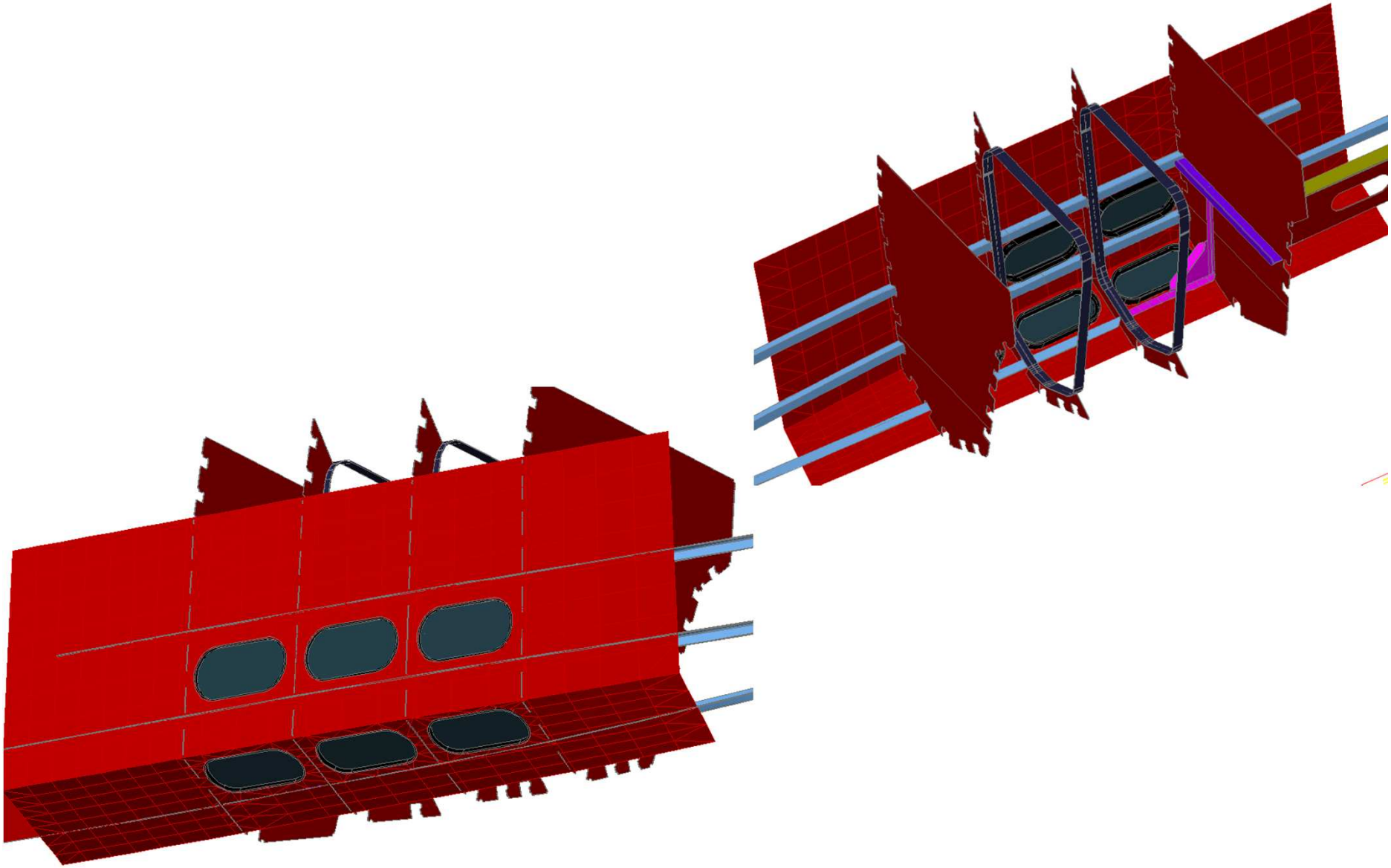
Electrical Diagrams Drawings



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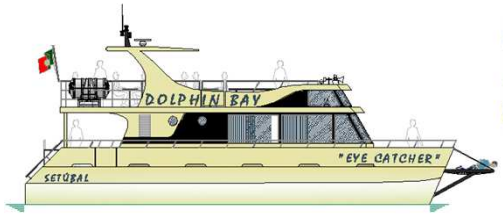

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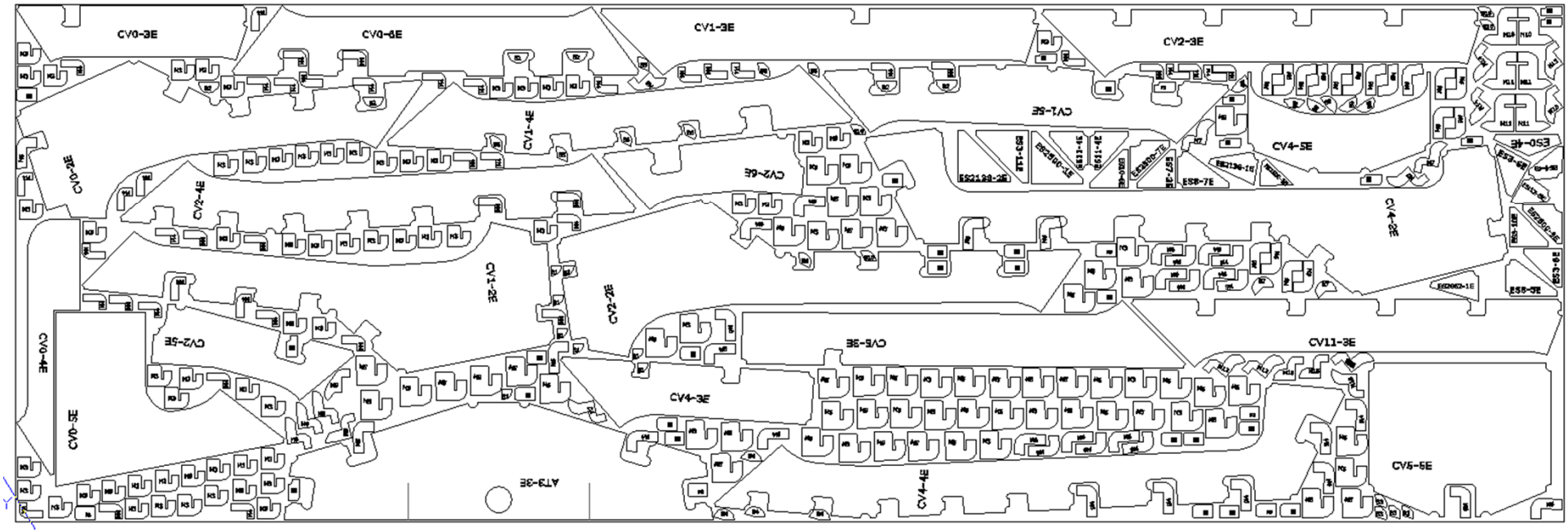
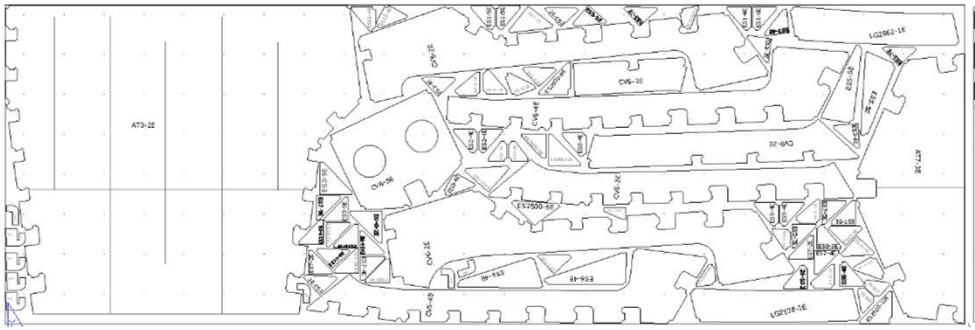
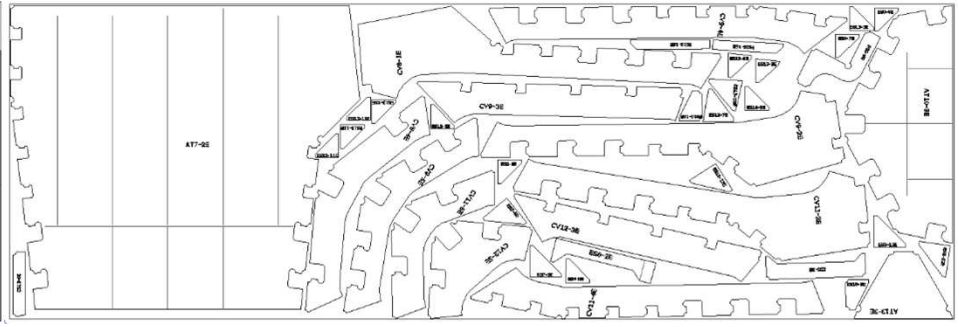
Nesting and profile cutting



Chapa de corte A14 - 6mm

Chapa de corte A15 - 6mm





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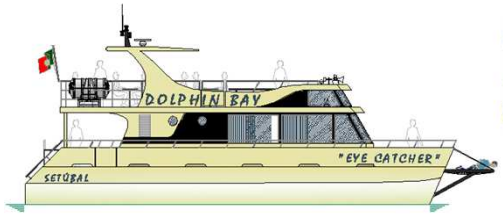

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4th Stage – Ship's construction

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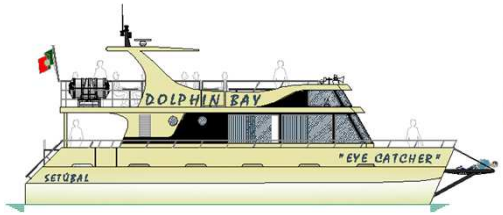

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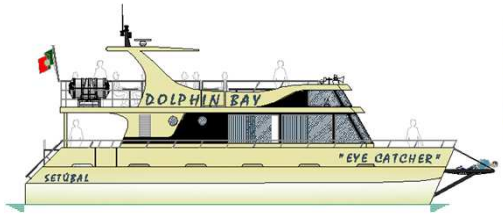

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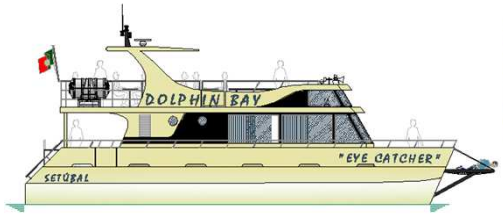

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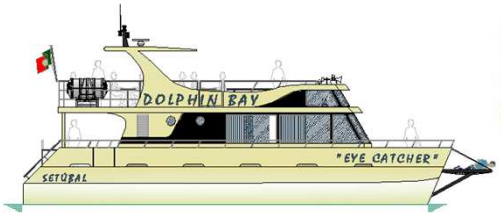

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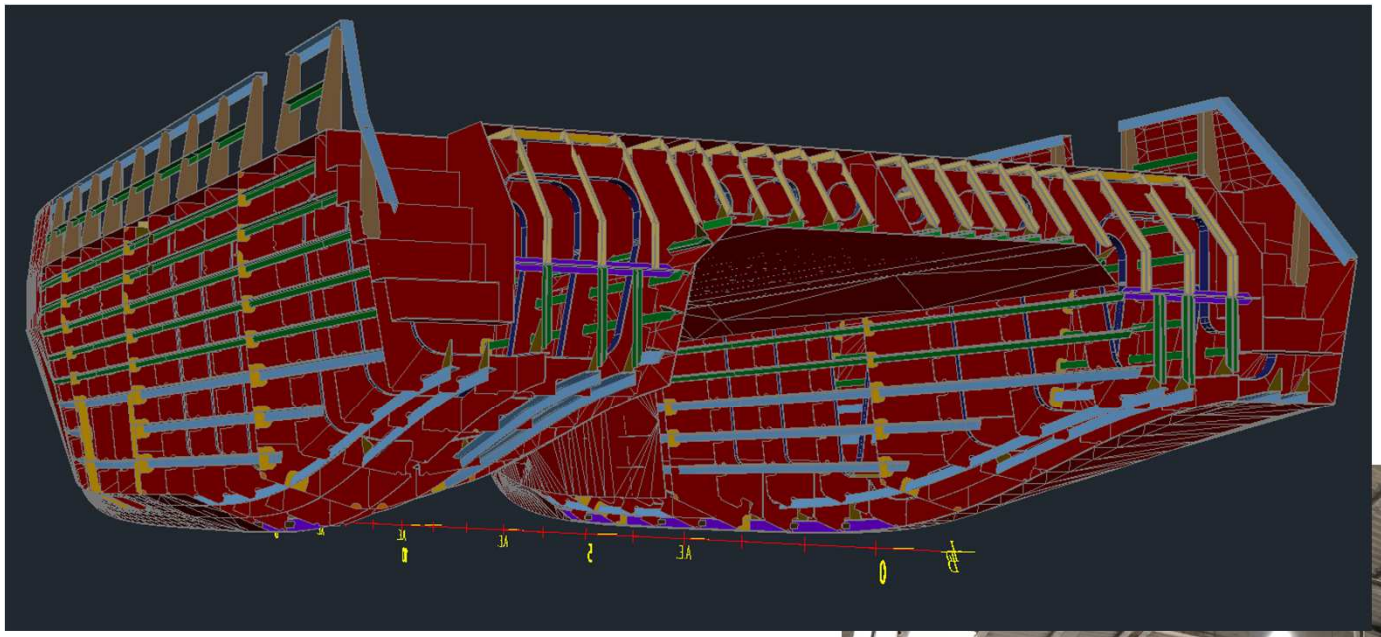
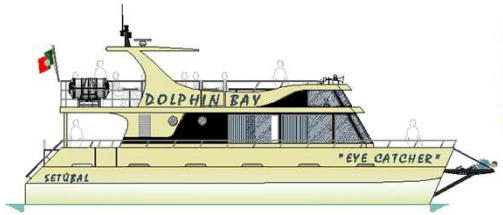


Coastal Catamaran Design



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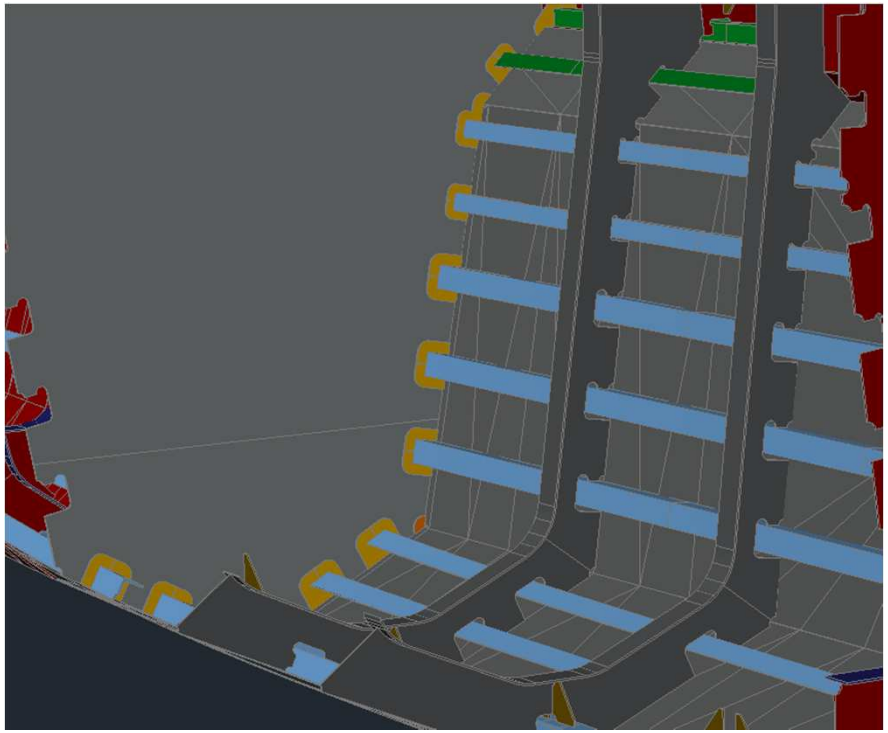

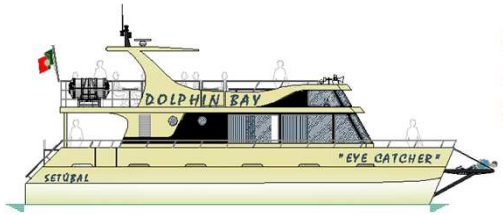

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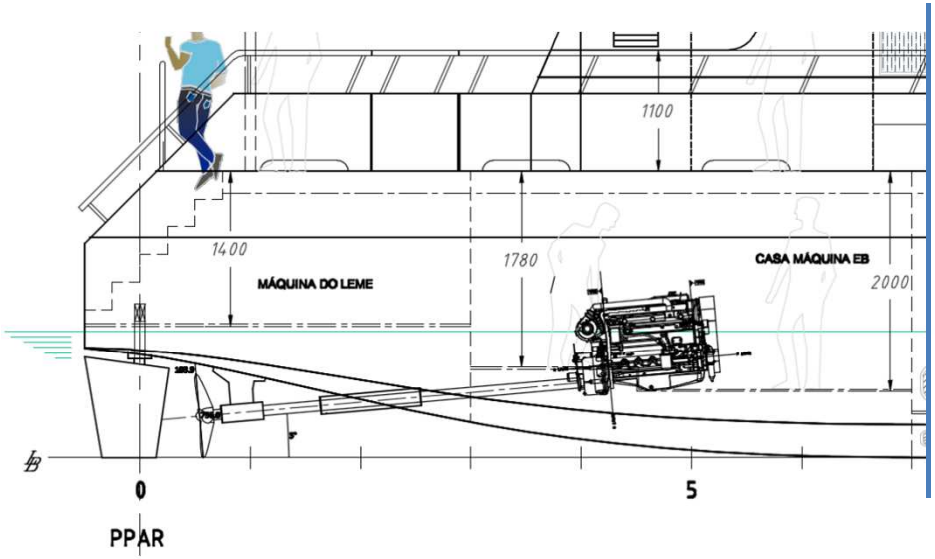
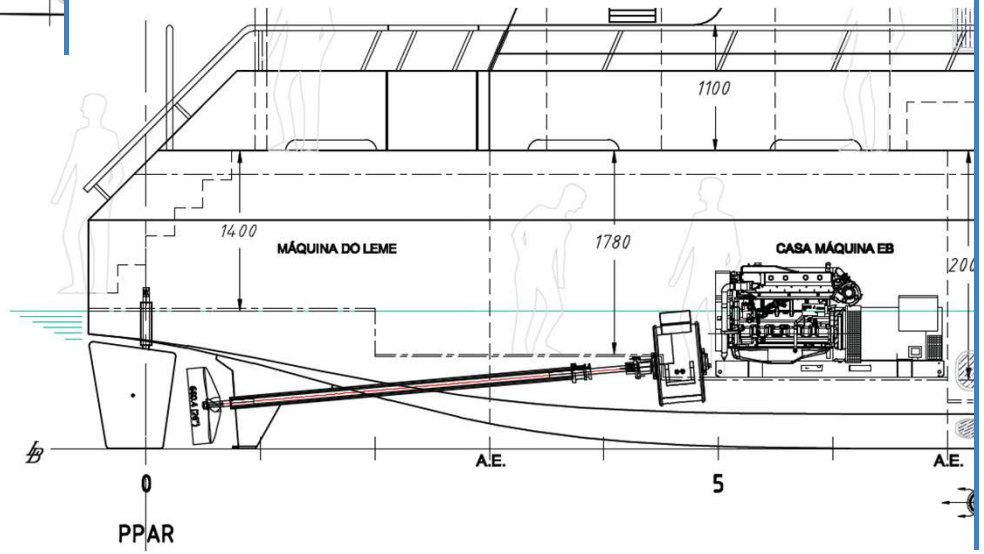
About the propulsion…

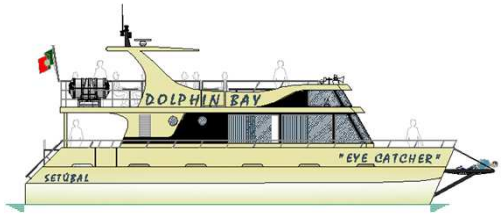
- ONE VESSEL WITH TRADITIONAL DIESEL ENGINES IN TWO SHAFT LINES ;



- OTHER WITH TWO 90 Kw ELECTRIC MOTORS;



Coastal Catamaran Design



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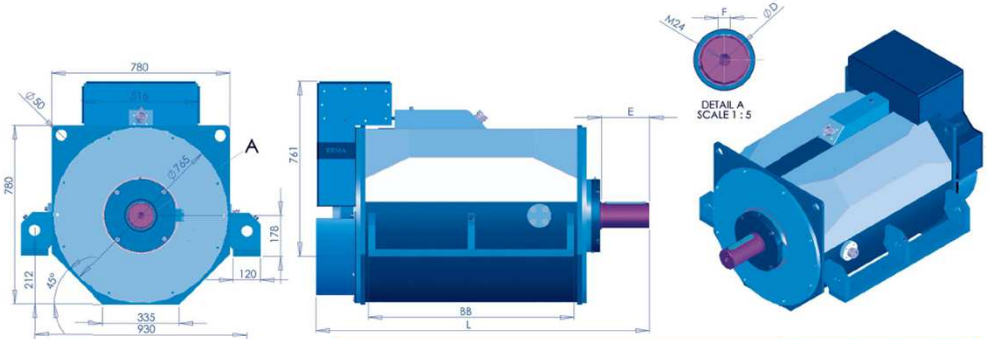
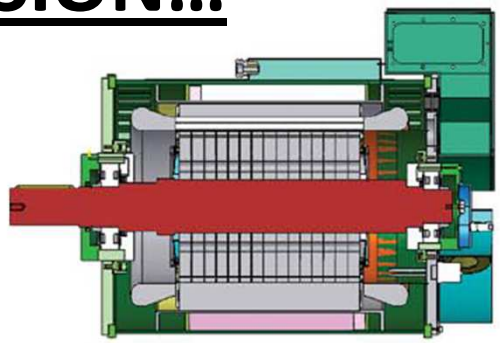
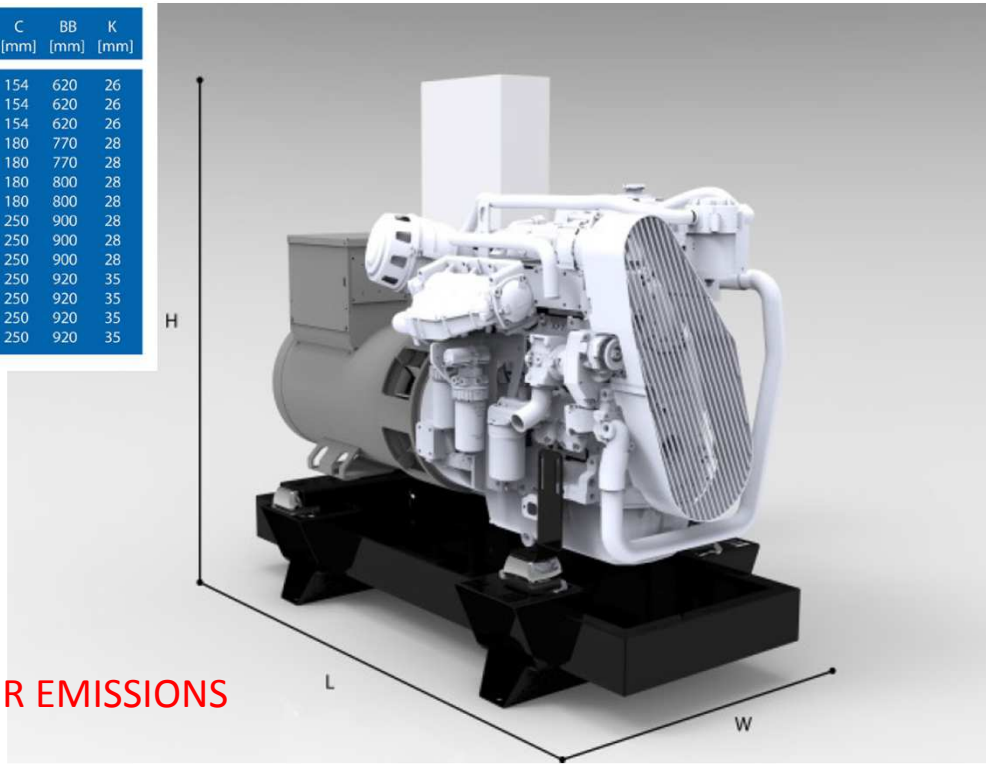
A LITTLE ABOUT ELECTRIC PROPULSION…





Motor Type	L [mm]	D [mm]	E [mm]	F [mm]	GA [mm]	A [mm]	B [mm]	C [mm]	BB [mm]	K [mm]
LPMR-350.6.07..	1164	85	130	22	90	155	464	154	620	26
LPMR-400.6.08..	1200	85	130	22	90	155	464	154	620	26
LPMR-450.6.09..	1236	95	155	25	100	155	464	154	620	26
LPMR-500.6.10..	1272	95	155	25	100	190	560	180	770	28
LPMR-550.6.11..	1308	95	155	25	100	190	560	180	770	28
LPMR-600.6.12..	1344	110	210	28	116	190	560	180	800	28
LPMR-650.6.13..	1380	110	210	28	116	190	560	180	800	28
LPMR-700.6.14..	1416	110	210	28	116	220	690	250	900	28
LPMR-750.6.15..	1452	110	210	28	116	220	690	250	900	28
LPMR-800.6.16..	1488	110	210	28	116	220	690	250	900	28
LPMR-850.6.17..	1524	120	210	32	127	230	710	250	920	35
LPMR-900.6.18..	1560	120	210	32	127	230	710	250	920	35
LPMR-950.6.19..	1596	120	210	32	127	230	710	250	920	35
LPMR-1000.6.20..	1632	120	210	32	127	230	710	250	920	35



THIS ELECTRIC PROPULSION IS IN FACT A DIRECT CONSUMPTION FROM MAIN SWITCHBOARD, POWERED BY AN ELECTRIC DIESEL GENERATOR SET

NO ENERGY SAVING/REDUCING AIR EMISSIONS

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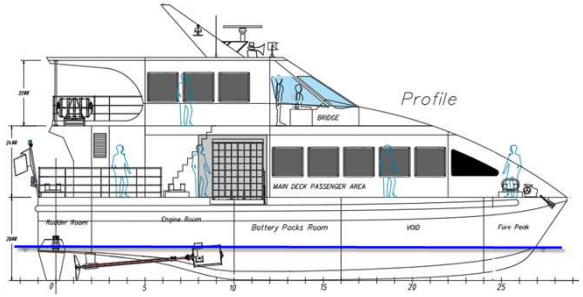
NEXT STEPS…

- OPTIMIZATION ON ENERGY CONSUMPTION
- SHORT TOURS AT SLOW CONSUMPTION RATES
- PASSENGERS/TOURISTS ARE SENSITIVE TO ENVIRONMENTAL ISSUES



- **HYBRID OR FULL ELECTRIC PROPULSION**
- **INCREASE THE DESIGN ON SHAPING OF THE HULL AND POWER PREDICTION**
- **HUGE SAVINGS ON DIESEL MAINTENANCE AND**
- **HUGE SAVINGS ON FUEL COSTS**

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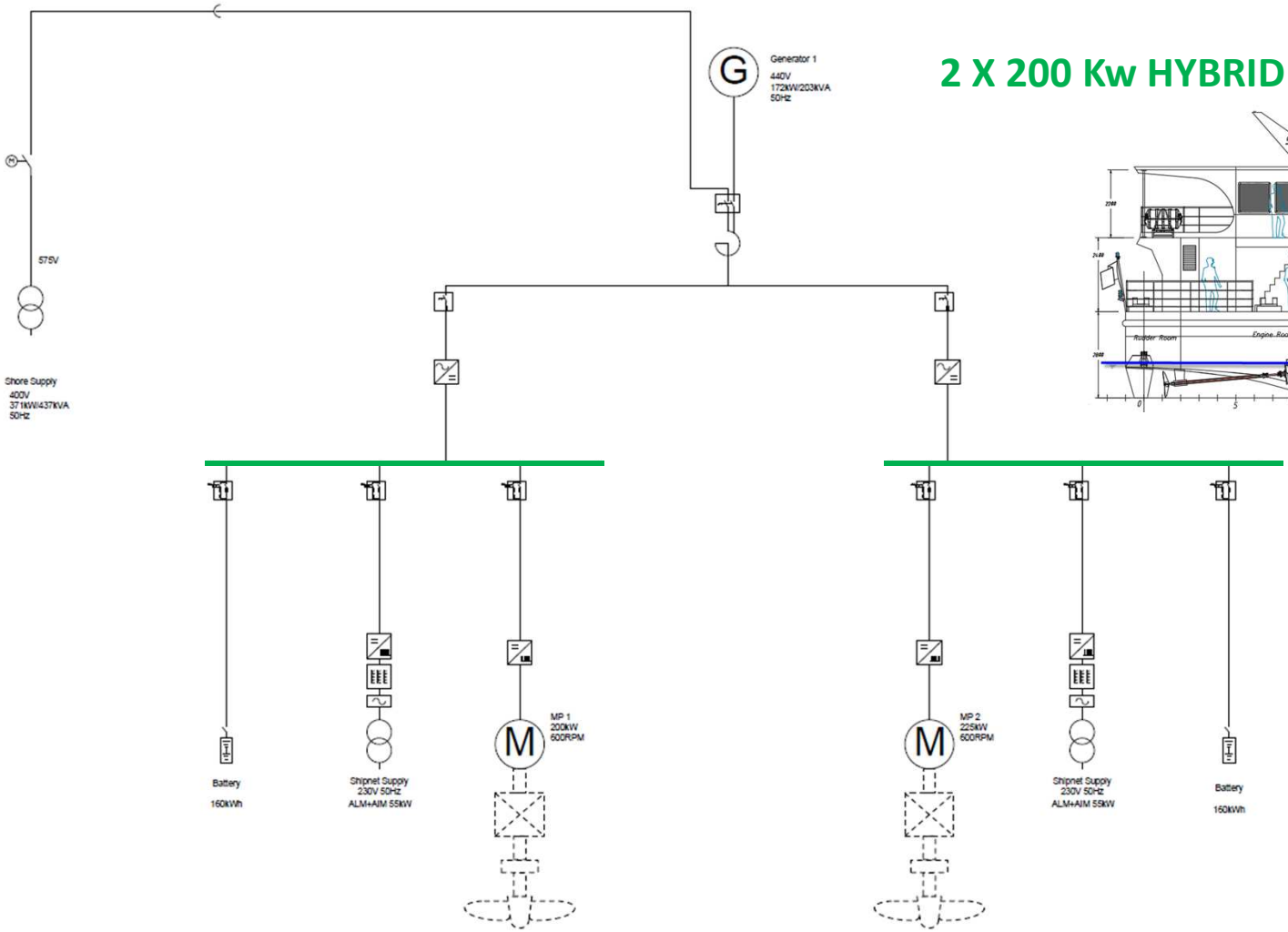
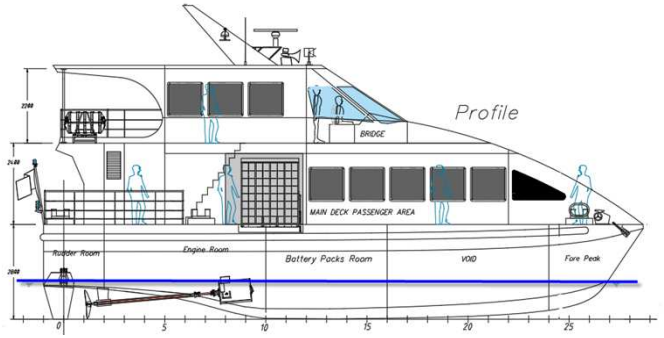
DISTRIBUTION SYSTEM BASED ON A DC MAIN SWITCHBOARD



2 X 200 Kw HYBRID PROPULSION SYSTEM



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NEXT STEPS IN ENGINNERING… DIGITAL TWIN

Apoyo a los clientes a todo lo largo del ciclo de vida

VERISTARAIM 3D

- Salpicaderos dedicados
- Calendario colaborativo
- Modo móvil para las intervenciones

- Importacion/construccion del gemelo digital
- Definicion de los criterios de aceptabilidad
- Gestion de proyecots
- Gestion de Control de Calidad

- Uso directo del gemelo digital
- Envio de informacion a los contrastista
- Comparativa de alternativas

THANK YOU