YILDIZ TECHNICAL UNIVERSITY
NAVAL ARCHITECTURE AND MARITIME FACULTY
DEPARTMENT OF NAVAL ARCHITECTURE AND MARINE ENGINEERING
BSc. GRADUATE THESIS

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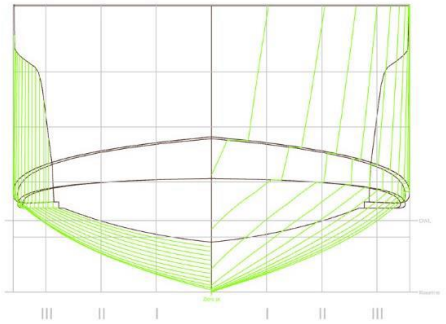
DESIGN OF MOTORYACHT SERIES IN 24M, 21M, 18M

Aims of the Thesis

The decision process in yacht design includes a number of parameters such as yacht type, characteristics, marine conditions, capacity, changing competition and market conditions of the commercial or private working areas preferred by the yacht owner.

The project aims to create a conceptual design by considering these parameters.

Calculations and Plans for Reference (24 M Motor Yacht)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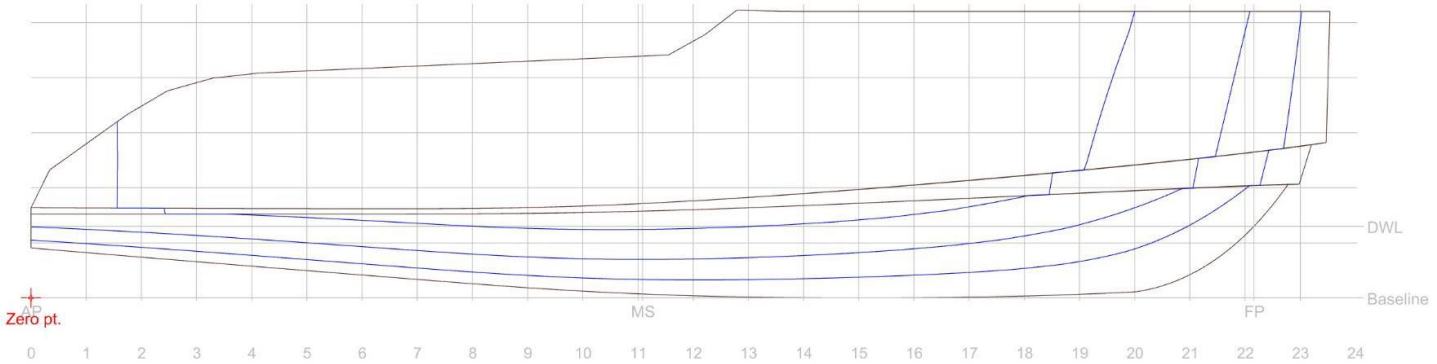
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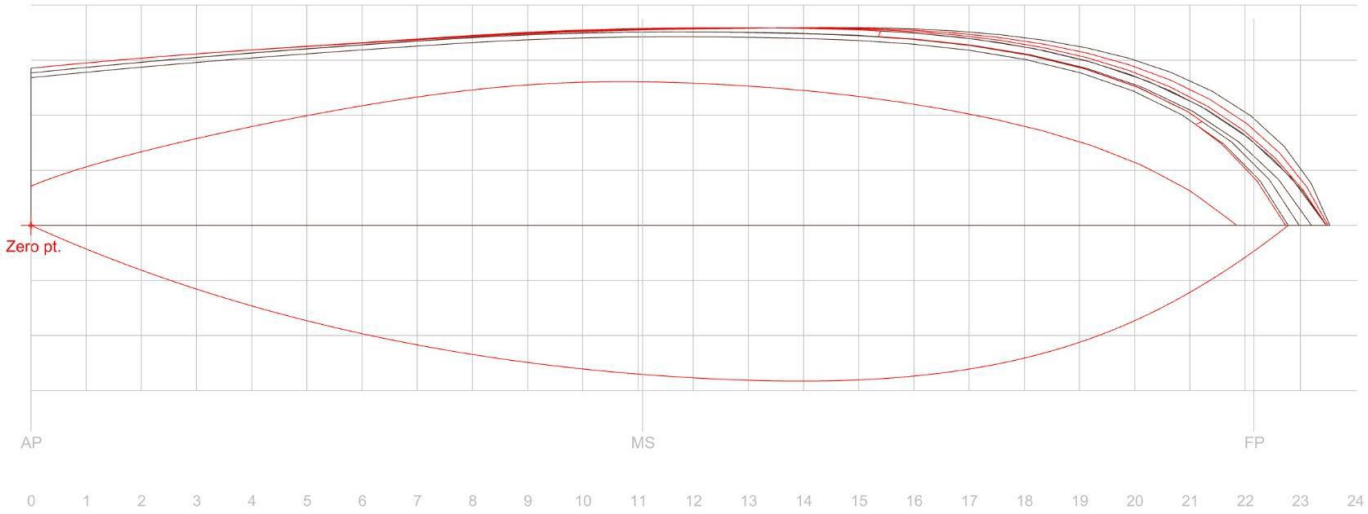
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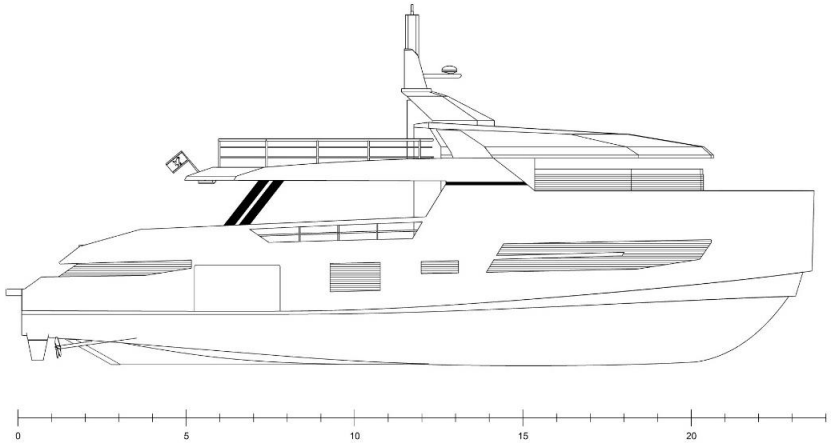
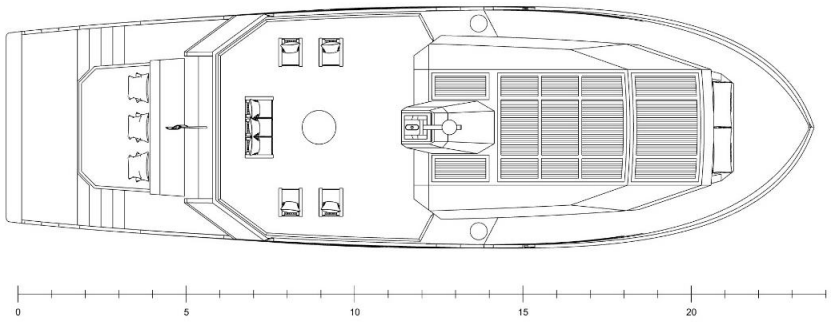
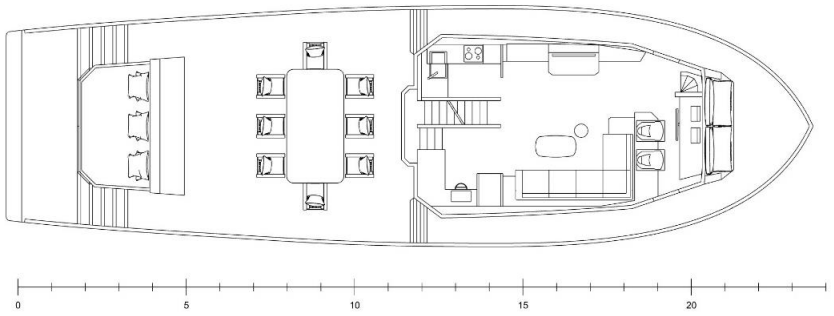
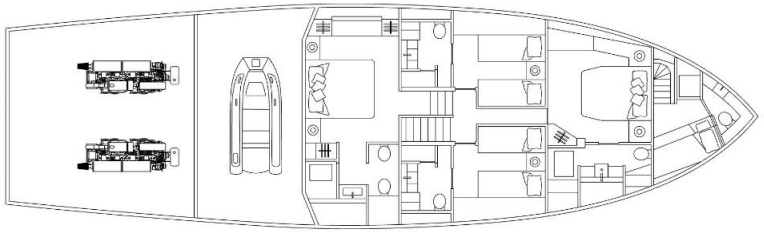


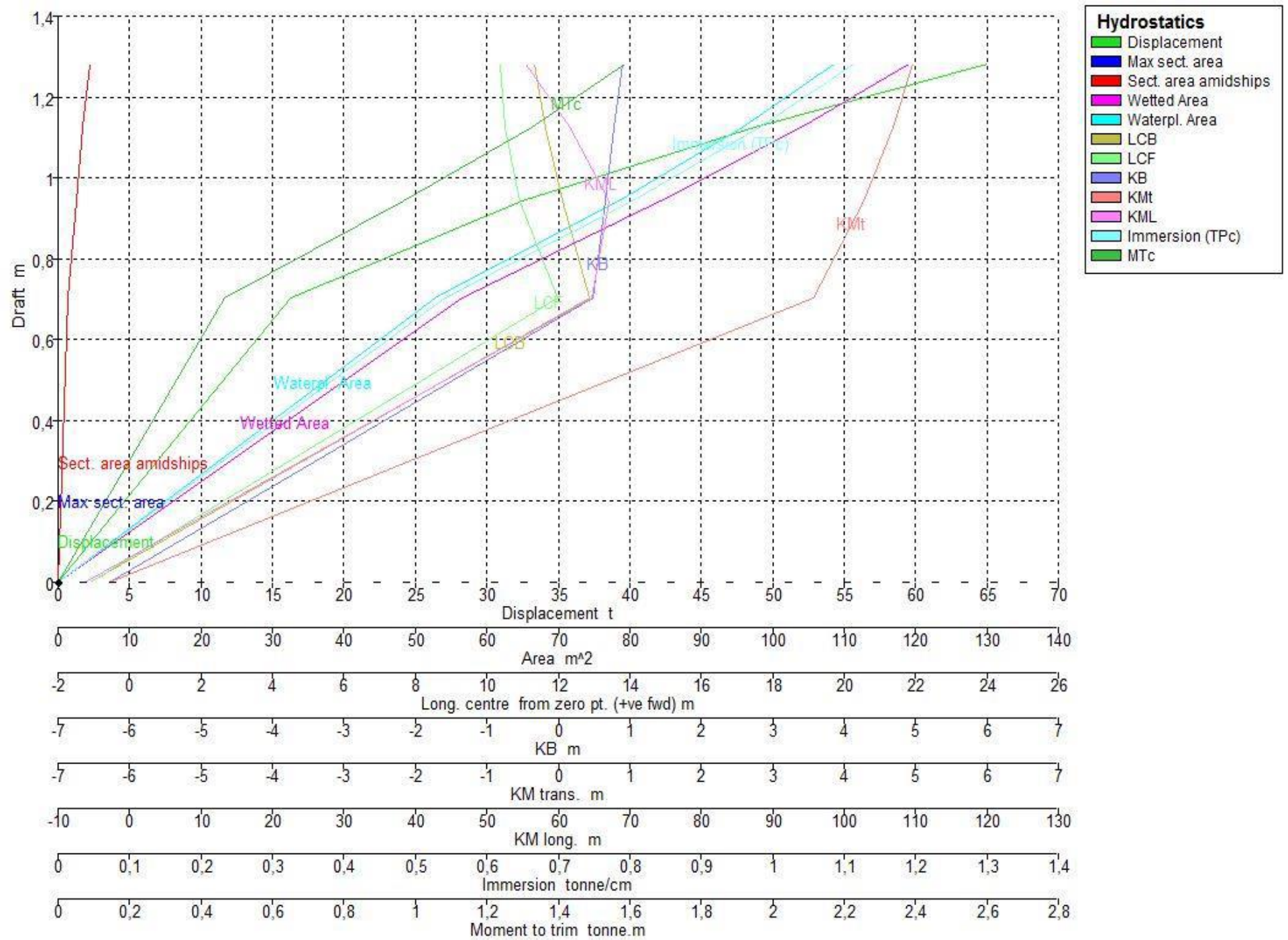






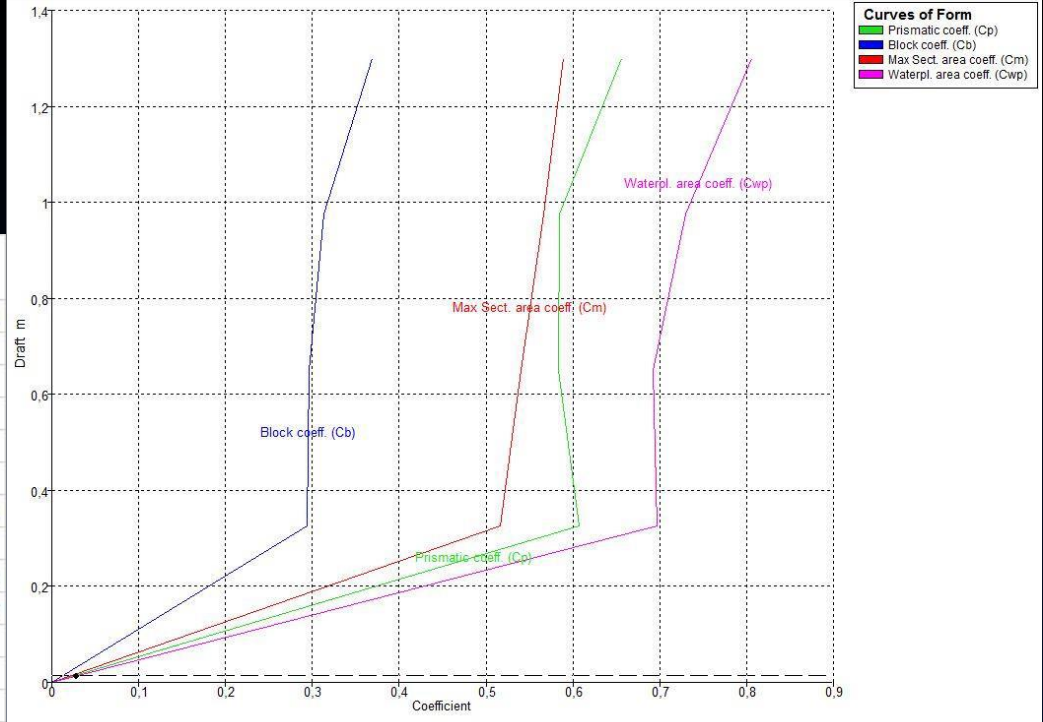
Weight Table

Item Name		Quantity	Unit Mass	Total Mass	Unit Volume	Total Volume	Long. Arm	Trans. Arm	Vert. Arm
Structures									
Steel Hull		1,000	26,000	26,000			13,000	0,000	2,500
Super Structure		1,000	9,000	9,000			16,500	0,000	5,700
Fin		2,000	1,000	2,000			0,500	0,000	1,000
Propeller		2,000	0,500	1,000			1,000	0,000	1,000
Engine Room									
Diesel Generator		2,000	1,000	2,000			3,500	0,000	1,000
Auxiliary Machinery		2,000	0,500	1,000			3,000	0,000	1,000
Outfitting									
Equipment		1,000	1,000	1,000			10,000	0,000	3,500
Doors		20,000	0,100	2,000			16,000	0,000	2,500
Lights		1,000	1,000	1,000			12,000	0,000	1,500
Solar Panel		1,000	3,000	3,000			12,000	0,000	5,500
Sun Deck									
Radar		2,000	0,100	0,200			10,000	0,000	5,500
Mast		1,000	1,000	1,000			10,000	0,000	6,500
Open Deck									
	Couch#1	1,000	0,100	0,100			7,100	0,000	6,300
	Couch#2	4,000	0,050	0,200			8,600	0,000	6,300
	Table	1,000	0,050	0,050			8,600	0,000	6,300
Main Deck									
Open Deck									
	Couch#1	1,000	0,050	0,050			7,100	0,000	3,800
	Couch#2	8,000	0,050	0,400			7,100	0,000	3,800
	Couch#3	1,000	0,100	0,100			3,800	0,000	3,800
	Table	1,000	0,100	0,100			7,100	0,000	3,800
	Sunpad	1,000	0,100	0,100			2,500	0,000	3,800
Main Saloon									
	Couch	1,000	0,050	0,050			14,800	1,200	4,400
	TV	1,000	0,020	0,020			14,700	-1,700	4,400
	Table#1	1,000	0,020	0,020			11,400	0,000	4,400
	Table#2	1,000	0,020	0,020			13,900	0,000	4,400
	Table#3	1,000	0,010	0,010			14,700	1,700	4,400
	Chair	1,000	0,050	0,050			11,500	-1,000	4,400
Galley		1,000	1,000	1,000			11,500	-1,000	4,400
Wheelhouse									
	Contr. Tabl	1,000	0,200	0,200			17,400	0,200	4,400
	Couch	2,000	0,100	0,200			16,200	0,200	4,400
Lower Deck									
Owner Suite									
	Bed	1,000	0,100	0,100			10,000	-0,800	1,400
	TV	1,000	0,050	0,050			10,000	-2,600	1,400
	Couch	1,000	0,050	0,050			10,000	1,000	1,400
	Toilet	1,000	0,100	0,100			10,400	1,800	1,400
	Wardrobe	3,000	0,050	0,150			10,200	-1,200	1,400
Guest Cabin #1									
	Bed	2,000	0,200	0,400			14,500	-1,350	1,400
	Toilet	1,000	0,100	0,100			12,500	-1,850	1,400
Guest Cabin #2									
	Bed	2,000	0,200	0,400			14,500	1,350	1,400
	Toilet	1,000	0,100	0,100			12,500	1,850	1,400
Guest Cabin #3									
	Bed	1,000	0,300	0,300			18,000	-0,800	1,400
	Toilet	1,000	0,100	0,100			18,000	1,200	1,400
Crew Cabin									
	Bed	2,000	0,100	0,200			20,000	1,200	1,400
	Toilet	1,000	0,100	0,100			21,000	0,000	1,400
Tender Garage									
	Tender	1,000	3,000	3,000			7,500	0,000	1,400
Tanks									
Fuel Tank PS 01			1,643	1,643	1,955	1,955	9,423	-0,671	0,510
Fuel Tank SB 01			1,643	1,643	1,955	1,955	9,423	0,671	0,510
Sewage Water PS			0,561	0,561	0,614	0,614	15,493	-0,574	0,462
Gray Water SB			0,561	0,561	0,614	0,614	15,493	0,574	0,462
Fresh Water SB			0,885	0,885	0,885	0,885	17,934	-0,440	0,474
Fresh Water SB			0,885	0,885	0,885	0,885	17,934	0,440	0,474
Fuel Tank PS 02			2,061	2,061	2,454	2,454	12,734	-0,670	0,467
Fuel Tank SB 02			2,061	2,061	2,454	2,454	12,734	0,670	0,467

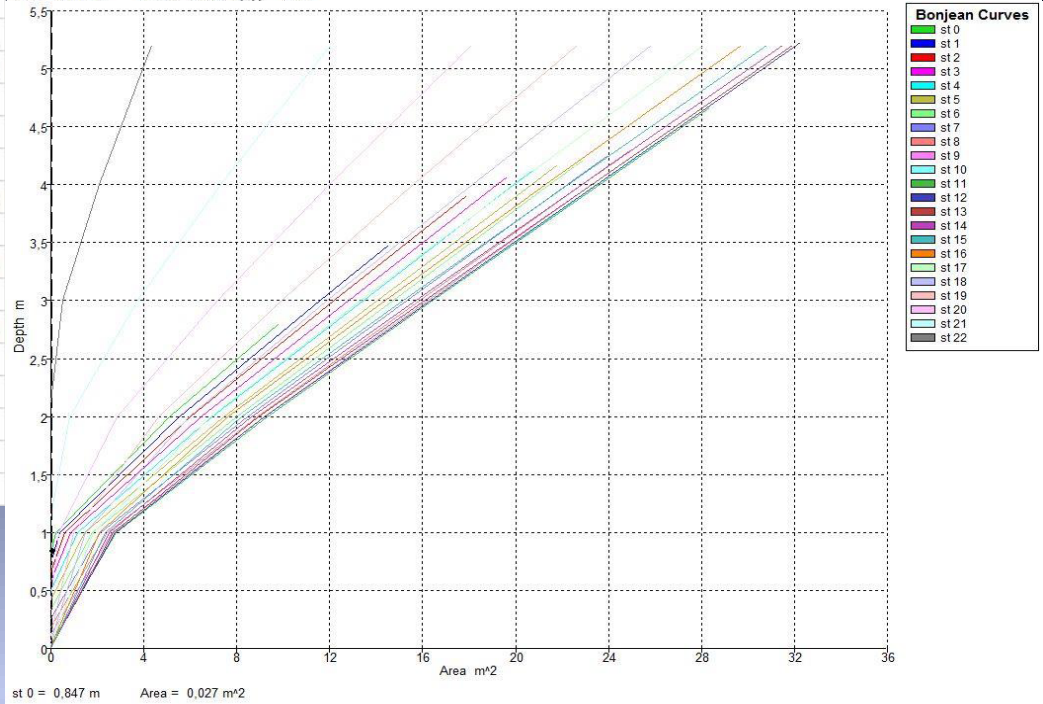


Draft = 0.000 m Displacement = 0.000 t

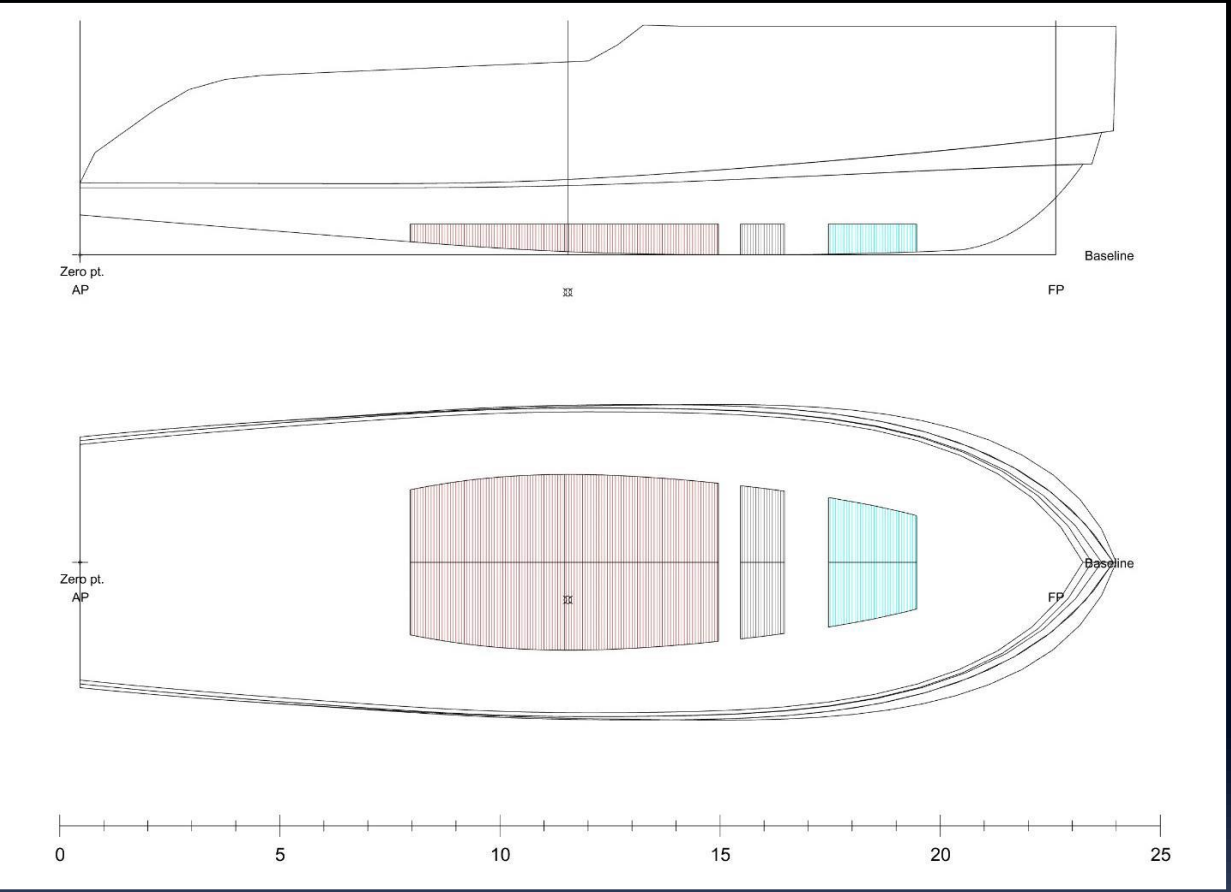
	Draft Amidship m	0,000	0,325	0,650	0,975	1,300
1	Displacement t	0,000	2,658	13,590	35,050	67,230
2	Heel deg	0,000	0,000	0,000	0,000	0,000
3	Draft at FP m	0,000	0,325	0,650	0,975	1,300
4	Draft at AP m	0,000	0,325	0,650	0,975	1,300
5	Draft at LCF m	0,000	0,325	0,650	0,975	1,300
6	Trim (+ve by stern) m	0,000	0,000	0,000	0,000	0,000
7	WL Length m	0,000	13,645	18,292	21,819	22,160
8	Beam max extents on WL m	0,000	1,991	3,767	5,129	6,169
9	Wetted Area m^2	0,000	20,154	51,029	87,902	121,008
10	Waterpl. Area m^2	0,000	18,926	47,717	81,659	110,193
11	Prismatic coeff. (Cp)	0,000	0,608	0,583	0,584	0,656
12	Block coeff. (Cb)	0,000	0,294	0,296	0,313	0,369
13	Max Sect. area coeff. (Cm)		0,517	0,541	0,566	0,589
14	Waterpl. area coeff. (Cwp)	0,000	0,697	0,692	0,730	0,806
15	LCB from zero pt. (+ve fwd) m	-1,114	14,022	13,013	12,044	11,311
16	LCF from zero pt. (+ve fwd) m	-1,114	13,567	12,185	10,822	10,342
17	KB m	-6,283	0,229	0,456	0,683	0,904
18	KG m	1,300	1,300	1,300	1,300	1,300
19	BMt m	0,000	1,665	2,937	3,670	4,081
20	BML m	0,000	74,580	64,331	66,025	53,768
21	GMt m	-7,583	0,594	2,094	3,053	3,686
22	GML m	-7,583	73,510	63,487	65,408	53,373
23	KMt m	-6,283	1,894	3,394	4,353	4,986
24	KML m	-6,283	74,810	64,787	66,708	54,673
25	Immersion (TPc) tonne/cm	0,000	0,194	0,489	0,837	1,129
26	MTc tonne.m	0,000	0,088	0,389	1,035	1,619
27	RM at 1deg = GMt.Disp.sin(1) tonne.m	0,000	0,028	0,497	1,868	4,324
28	Max deck inclination deg	0,000	0,000	0,000	0,000	0,000
29	Trim angle (+ve by stern) deg	0,000	0,000	0,000	0,000	0,000



Draft = 0,014 m Prismatic coeff. (Cp) = 0,027

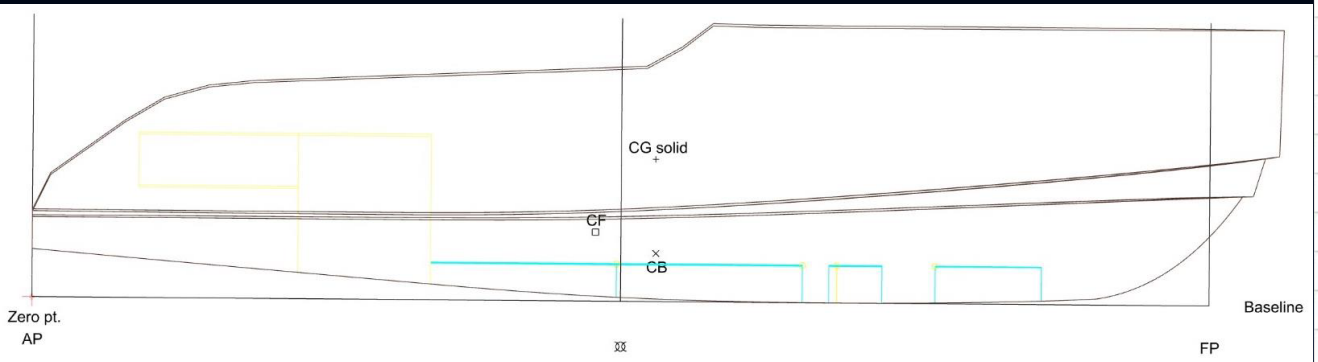


st 0 = 0,847 m Area = 0,027 m^2



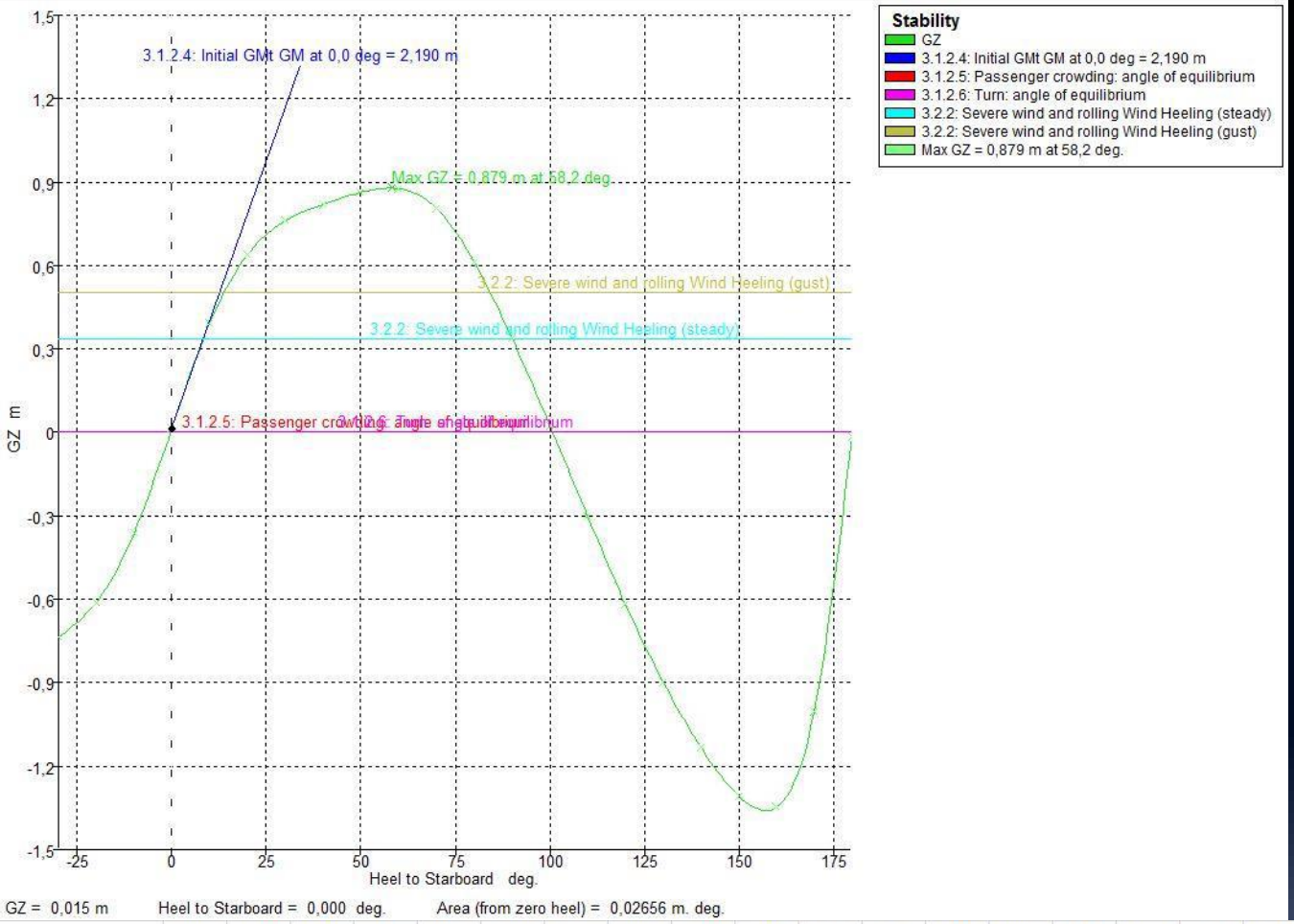
Tank Name	Total Mass tonne	Total Volume m^3	Specific Gravity	Fluid Type	Long. Arm m	Trans. Arm m	Vert. Arm m
Fuel Tank PS_01	1,643	1,955	0,84	Diesel	9,423	-0,671	0,51
Fuel Tank SB_01	1,643	1,955	0,84	Diesel	9,423	0,671	0,51
Fuel Tank PS_02	2,061	0,614	0,84	Diesel	15,493	-0,574	0,462
Fuel Tank SB_02	2,061	0,614	0,84	Diesel	15,493	0,574	0,462
Sewage Water PS	0,561	0,885	0,913	Slops	17,934	-0,44	0,474
Gray Water SB	0,561	0,885	0,913	Slops	17,934	0,44	0,474
Fresh Water SB	0,885	2,454	1	Fresh Water	12,734	-0,67	0,467
Fresh Water SB	0,885	2,454	1	Fresh Water	12,734	0,67	0,467

Loadcase 1 – Departure (Fuels, Fresh Water Full)



Disp:66.20 t, Tamid: 1,295 m, Trim: -0,144 m, Heel: -0,4 deg (stbd)

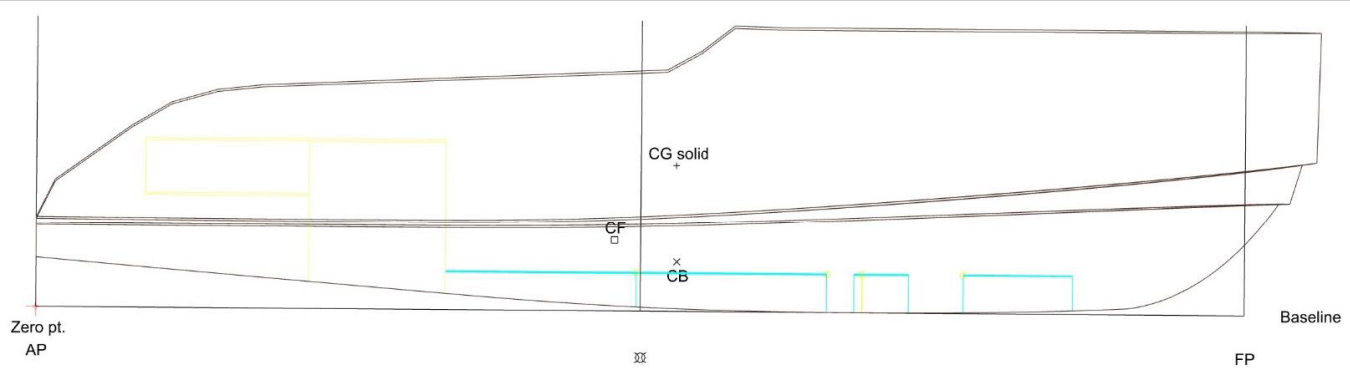
	Loadcase - Departure	
1	Draft Amidships m	1,306
2	Displacement t	67,32
3	Heel deg	-0,4
4	Draft at FP m	1,395
5	Draft at AP m	1,216
6	Draft at LCF m	1,302
7	Trim (+ve by stern) m	-0,18
8	WL Length m	22,25
9	Beam max extents on WL m	6,176
10	Wetted Area m^2	120,3
11	Waterpl. Area m^2	109,6
12	Prismatic coeff. (Cp)	0,644
13	Block coeff. (Cb)	0,356
14	Max Sect. area coeff. (Cm)	0,585
15	Waterpl. area coeff. (Cwp)	0,797
16	LCB from zero pt. (+ve fwd) m	11,74
17	LCF from zero pt. (+ve fwd) m	10,6
18	KB m	0,907
19	KG solid m	2,682
20	BMt m	4,003
21	BML m	53,16
22	GMt corrected m	2,228
23	GML m	51,39
24	KMt m	4,91
25	KML m	54,07
26	Immersion (TPc) tonne/cm	1,123
27	MTc tonne.m	1,561
28	RM at 1deg = GMt.Disp.sin(1) tonne.m	2,618
29	Max deck inclination deg	0,584
30	Trim angle (+ve by stern) deg	-0,46



GZ = 0,015 m Heel to Starboard = 0,000 deg. Area (from zero heel) = 0,02656 m. deg.

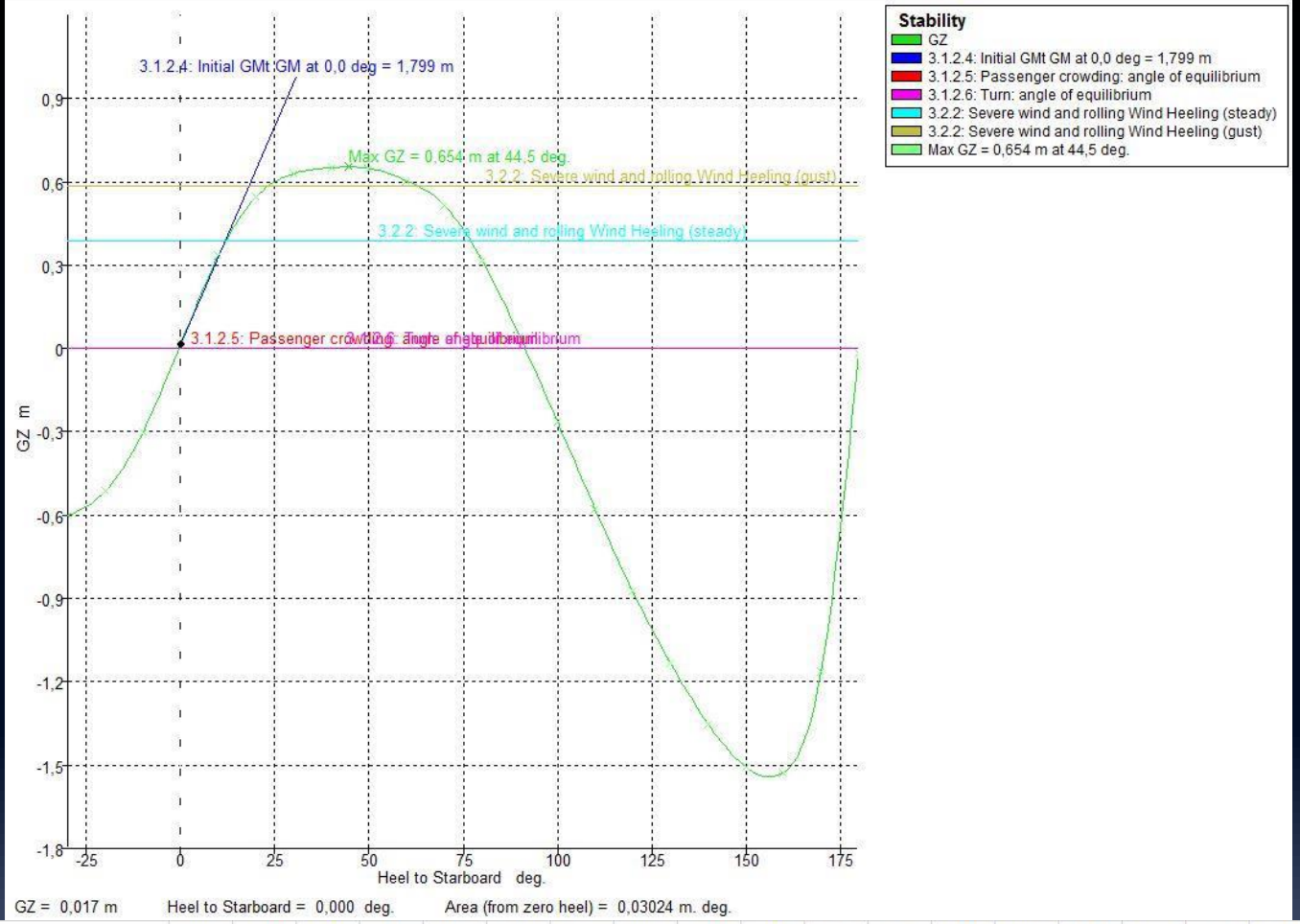
	Heel to Starboard deg	-30,0	-20,0	-10,0	0,0	10,0	20,0	30,0	40,0	50,0	60,0	70,0	80,0	90,0	100,0	110,0	120,0	130,0	140,0	150,0	160,0	170,0	180,0
1	GZ m	-0,74	-0,61	-0,36	0,015	0,391	0,638	0,761	0,821	0,863	0,877	0,808	0,612	0,339	0,025	-0,3	-0,62	-0,9	-1,13	-1,31	-1,35	-1	-0,02
2	Area under GZ curve from zero heel m.deg	13,59	6,797	1,805	0,027	2,097	7,367	14,45	22,38	30,81	39,55	48,07	55,26	60,06	61,91	60,53	55,92	48,32	38,13	25,86	12,41	0,166	-5,28
3	Displacement t	66,19	66,2	66,2	66,2	66,2	66,2	66,2	66,2	66,2	66,2	66,2	66,19	66,2	66,2	66,2	66,2	66,19	66,2	66,2	66,2	66,2	66,2
4	Draft at FP m	1,02	1,214	1,331	1,367	1,33	1,214	1,02	0,723	0,24	-0,73	-2,93	-9,58	n/a	-16,9	-10,2	-7,92	-6,77	-6,09	-5,64	-5,34	-5,17	-5,15
5	Draft at AP m	0,586	0,911	1,127	1,223	1,128	0,911	0,585	0,098	-0,67	-1,94	-4,36	-11,3	n/a	-15,4	-8,56	-6,18	-4,93	-4,15	-3,63	-3,29	-3,12	-3,1
6	WL Length m	21,87	22,08	22,19	22,22	22,19	22,08	21,87	21,69	21,77	21,64	21,44	21,22	21,59	22,01	22,3	22,56	22,8	22,93	23	23,03	22,6	21,21
7	Beam max extents on WL m	5,214	5,452	5,952	6,148	5,952	5,452	5,214	5,234	5,491	5,534	5,028	4,599	4,339	4,212	4,198	4,295	4,454	4,618	5,013	6,016	7,289	7,178
8	Wetted Area m^2	111,7	115	119,7	119,5	119,7	115	111,7	109,8	109,1	107,8	106,3	104,8	104,1	103,6	103,5	103,8	104	104,5	108,1	117,3	141,1	156,9
9	Waterpl. Area m^2	93,6	98,78	107,1	108,9	107,1	98,77	93,6	91,35	91,34	89,03	81,09	74,23	70,12	67,92	67,49	68,68	71,66	73,15	77,96	90,11	119,1	136,4
10	Prismatic coeff. (Cp)	0,653	0,649	0,645	0,644	0,645	0,649	0,653	0,651	0,641	0,633	0,626	0,624	0,606	0,589	0,576	0,564	0,552	0,538	0,517	0,483	0,435	0,453
11	Block coeff. (Cb)	0,498	0,506	0,391	0,357	0,391	0,506	0,498	0,417	0,349	0,338	0,388	0,461	0,545	0,434	0,363	0,315	0,284	0,27	0,259	0,242	0,258	0,453
12	LCB from zero pt. (+ve fwd) m	11,7	11,69	11,68	11,67	11,68	11,69	11,7	11,71	11,73	11,73	11,72	11,7	11,67	11,63	11,59	11,55	11,52	11,49	11,48	11,49	11,5	11,51
13	LCF from zero pt. (+ve fwd) m	11,24	10,97	10,65	10,56	10,65	10,97	11,24	11,52	11,76	11,7	11,73	11,73	11,7	11,61	11,49	11,32	11,08	10,99	10,98	11,02	11,04	11,44
14	Max deck inclination deg	30,01	20,01	10,01	0,371	10,01	20,01	30,01	40,02	50,02	60,01	70,01	80	90	100	110	120	129,9	139,8	149,7	159,4	168,7	174,7
15	Trim angle (+ve by stern) deg	-1,12	-0,79	-0,53	-0,37	-0,52	-0,79	-1,12	-1,61	-2,34	-3,12	-3,7	-4,34	-1,#INI	3,679	4,18	4,482	4,756	5,007	5,176	5,277	5,3	5,271

Loadcase 2 – Arrival (Gray Water, Black Water Full)



Disp:58.14 t, Tamid: 1,219 m, Trim: -0,056 m, Heel: -0,5 deg (stbd)

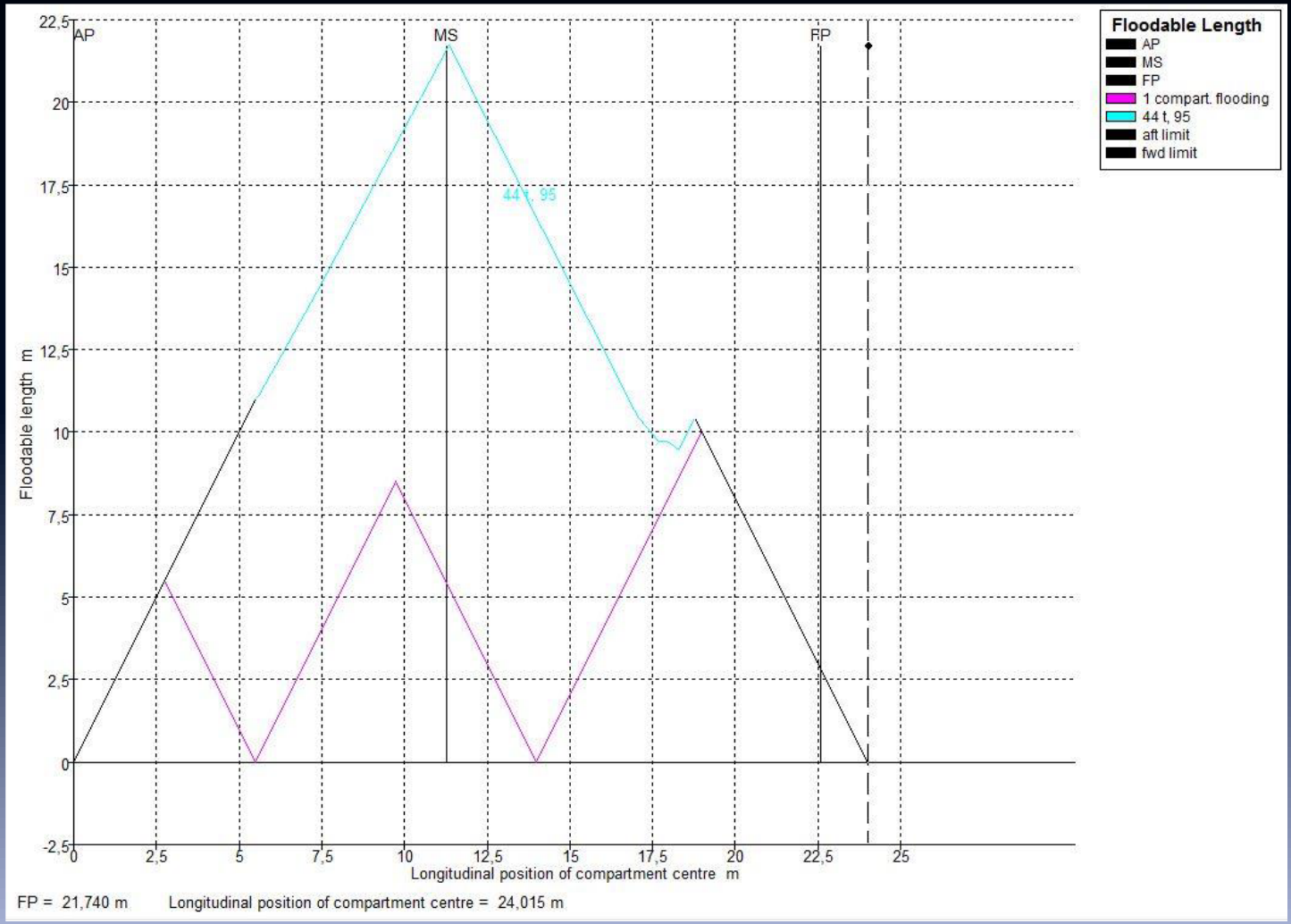
	Loadcase - Arrival	
1	Draft Amidships m	1,306
2	Displacement t	67,32
3	Heel deg	-0,4
4	Draft at FP m	1,395
5	Draft at AP m	1,216
6	Draft at LCF m	1,302
7	Trim (+ve by stern) m	-0,18
8	WL Length m	22,25
9	Beam max extents on WL m	6,176
10	Wetted Area m^2	120,3
11	Waterpl. Area m^2	109,6
12	Prismatic coeff. (Cp)	0,644
13	Block coeff. (Cb)	0,356
14	Max Sect. area coeff. (Cm)	0,585
15	Waterpl. area coeff. (Cwp)	0,797
16	LCB from zero pt. (+ve fwd) m	11,74
17	LCF from zero pt. (+ve fwd) m	10,6
18	KB m	0,907
19	KG solid m	2,682
20	BMt m	4,003
21	BML m	53,16
22	GMt corrected m	2,228
23	GML m	51,39
24	KMt m	4,91
25	KML m	54,07
26	Immersion (TPc) tonne/cm	1,123
27	MTc tonne.m	1,561
28	RM at 1deg = GMt.Disp.sin(1) tonne.m	2,618
29	Max deck inclination deg	0,584
30	Trim angle (+ve by stern) deg	-0,46



GZ = 0,017 m Heel to Starboard = 0,000 deg. Area (from zero heel) = 0,03024 m. deg.

	Heel to Starboard deg	-30,0	-20,0	-10,0	0,0	10,0	20,0	30,0	40,0	50,0	60,0	70,0	80,0	90,0	100,0	110,0	120,0	130,0	140,0	150,0	160,0	170,0	180,0
1	GZ m	-0,6	-0,51	-0,3	0,017	0,333	0,545	0,631	0,651	0,649	0,603	0,516	0,316	0,044	-0,26	-0,58	-0,87	-1,13	-1,35	-1,51	-1,53	-1,16	-0,02
2	Area under GZ curve from zero heel m.deg	11,29	5,65	1,467	0,03	1,799	6,298	12,26	18,7	25,22	31,51	37,18	41,43	43,27	42,18	37,97	30,68	20,62	8,166	-6,2	-21,5	-35,5	-41,9
3	Displacement t	58,14	58,14	58,14	58,15	58,14	58,14	58,14	58,14	58,14	58,14	58,14	58,14	58,14	58,14	58,14	58,14	58,14	58,14	58,14	58,14	58,14	58,14
4	Draft at FP m	0,889	1,091	1,211	1,247	1,211	1,091	0,889	0,582	0,08	-0,95	-3,27	-10,3	n/a	-17,7	-10,6	-8,2	-6,99	-6,26	-5,78	-5,44	-5,25	-5,2
5	Draft at AP m	0,52	0,861	1,091	1,191	1,091	0,861	0,52	0,012	-0,78	-2,08	-4,58	-11,7	n/a	-16	-8,83	-6,36	-5,06	-4,26	-3,73	-3,37	-3,18	-3,16
6	WL Length m	21,71	21,95	22,07	22,11	22,07	21,95	21,71	21,46	21,58	21,45	21,25	20,97	21,38	21,79	22,14	22,39	22,63	22,73	22,79	22,81	22,34	20,5
7	Beam max extents on WL m	5,083	5,322	5,828	5,932	5,828	5,322	5,083	5,099	5,205	5,236	4,975	4,542	4,278	4,143	4,118	4,201	4,341	4,386	4,768	5,733	7,289	7,179
8	Wetted Area m^2	106,2	109,6	113,8	112,8	113,8	109,6	106,2	104	101,9	100,9	100,5	99	98,16	97,63	97,47	97,56	97	97,35	100,7	109,2	131,9	151,8
9	Waterpl. Area m^2	90,09	95,38	103,1	103,4	103	95,38	90,09	87,44	85,59	84,15	78,89	72,21	68,09	65,82	65,21	66,13	67,96	68,18	72,61	83,83	111,7	132,9
10	Prismatic coeff. (Cp)	0,643	0,639	0,636	0,636	0,636	0,639	0,643	0,645	0,634	0,629	0,62	0,618	0,598	0,581	0,566	0,554	0,542	0,528	0,507	0,472	0,418	0,438
11	Block coeff. (Cb)	0,49	0,501	0,381	0,352	0,381	0,501	0,49	0,406	0,347	0,335	0,371	0,45	0,542	0,423	0,35	0,302	0,272	0,265	0,254	0,237	0,24	0,439
12	LCB from zero pt. (+ve fwd) m	11,63	11,62	11,61	11,6	11,61	11,62	11,63	11,65	11,66	11,67	11,66	11,63	11,6	11,56	11,52	11,48	11,45	11,43	11,43	11,44	11,45	11,46
13	LCF from zero pt. (+ve fwd) m	11,21	10,9	10,55	10,49	10,55	10,9	11,21	11,51	11,66	11,57	11,6	11,6	11,57	11,48	11,35	11,16	10,94	10,91	10,91	10,94	10,98	11,34
14	Max deck inclination deg	30,01	20,01	10	0,145	10	20,01	30,01	40,01	50,01	60,01	70	80	90	100	110	120	129,9	139,8	149,7	159,4	168,7	174,7
15	Trim angle (+ve by stern) deg	-0,95	-0,6	-0,31	-0,15	-0,31	-0,59	-0,95	-1,47	-2,22	-2,92	-3,39	-3,69	-1,#INI	4,386	4,554	4,752	4,977	5,166	5,278	5,337	5,334	5,266

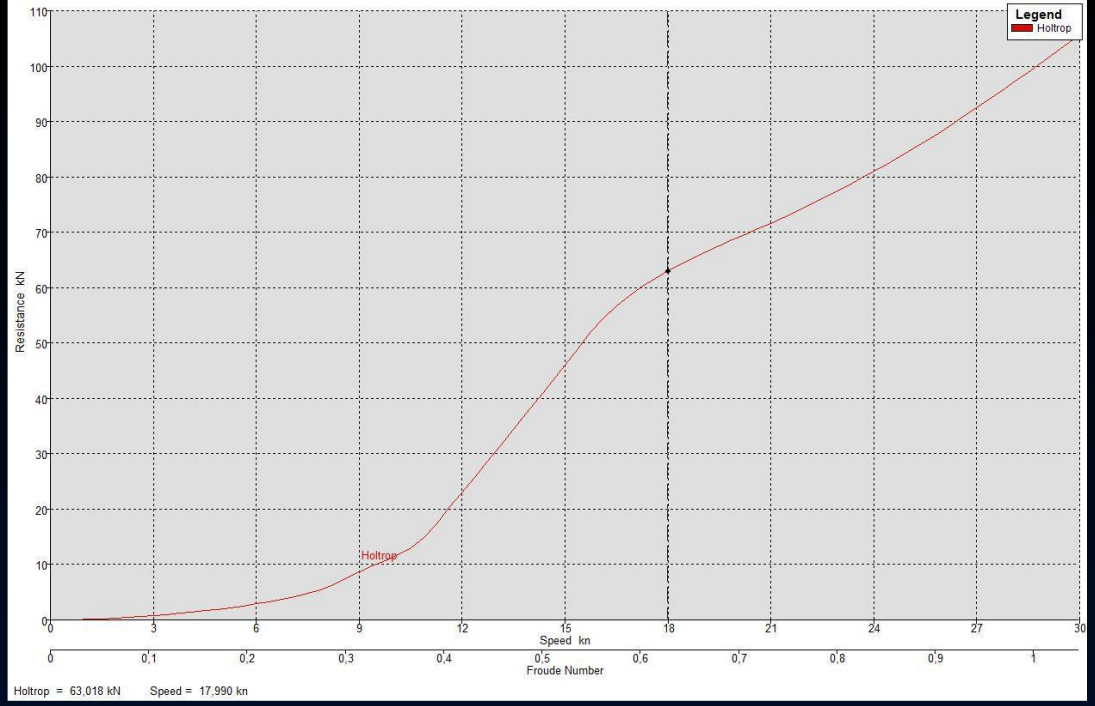
Floodable Length Graph and Bulkhead Locations



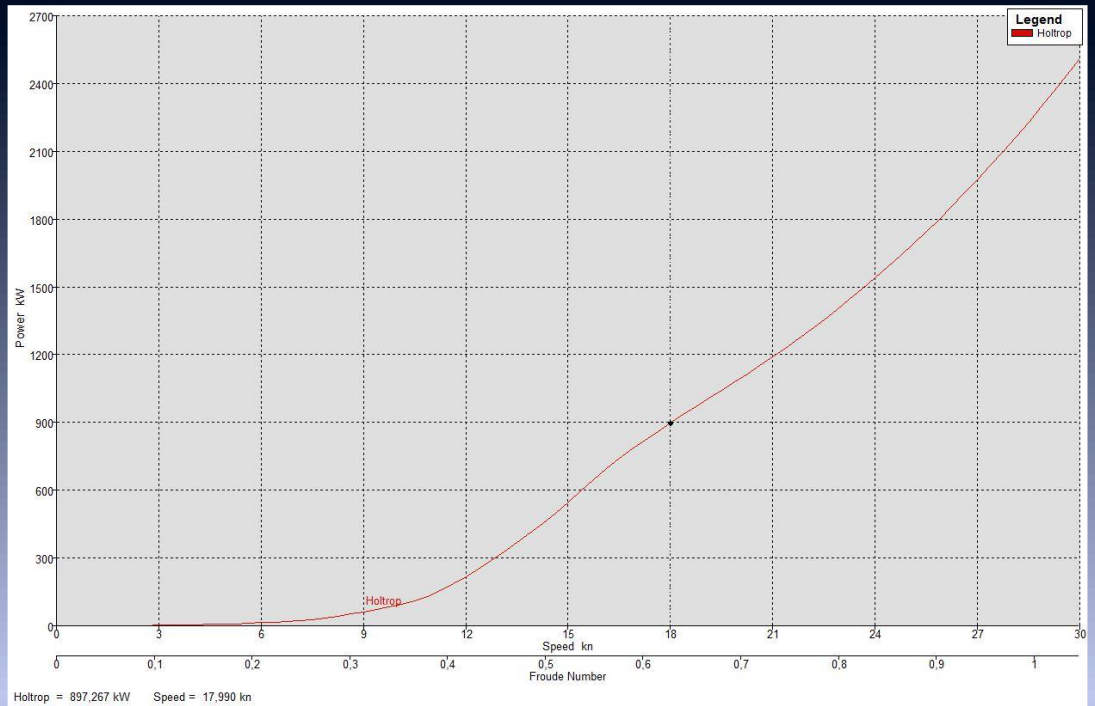
IMO Criteria

IMO CRITERIA						
A.749(18) Ch3 - Design criteria applicable to all ships	3.1.2.1: Area 0 to 30				Pass	
	from the greater of					
	spec. heel angle	0	deg	0		
	to the lesser of					
	spec. heel angle	30	deg	30		
	angle of vanishing stability	102	deg			
	shall not be less than (>=)	3,1513	m.deg	14,6733	Pass	365,63
A.749(18) Ch3 - Design criteria applicable to all ships	3.1.2.1: Area 0 to 40				Pass	
	from the greater of					
	spec. heel angle	0	deg	0		
	to the lesser of					
	spec. heel angle	40	deg	40		
	first downflooding angle	n/a	deg			
	angle of vanishing stability	102	deg			
	shall not be less than (>=)	5,1566	m.deg	22,7816	Pass	341,79
A.749(18) Ch3 - Design criteria applicable to all ships	3.1.2.1: Area 30 to 40				Pass	
	from the greater of					
	spec. heel angle	30	deg	30		
	to the lesser of					
	spec. heel angle	40	deg	40		
	first downflooding angle	n/a	deg			
	angle of vanishing stability	102	deg			
	shall not be less than (>=)	1,7189	m.deg	8,1083	Pass	371,71
A.749(18) Ch3 - Design criteria applicable to all ships	3.1.2.2: Max GZ at 30 or greater				Pass	
	in the range from the greater of					
	spec. heel angle	30	deg	30		
	to the lesser of					
	spec. heel angle	90	deg			
	angle of max. GZ	59,1	deg	59,1		
	shall not be less than (>=)	0,2	m	0,912	Pass	356
	Intermediate values					
	angle at which this GZ occurs		deg	59,1		
A.749(18) Ch3 - Design criteria applicable to all ships	3.1.2.3: Angle of maximum GZ				Pass	
	shall not be less than (>=)	25	deg	59,1	Pass	136,36
A.749(18) Ch3 - Design criteria applicable to all ships	3.1.2.4: Initial GMt				Pass	
	spec. heel angle	0	deg			
	shall not be less than (>=)	0,15	m	2,228	Pass	1385,33
A.749(18) Ch3 - Design criteria applicable to all ships	3.1.2.5: Passenger crowding: angle of equilibrium				Pass	
	Pass. crowding arm = nPass M / disp. D cos^n(phi)					
	number of passengers: nPass =	0				
	passenger mass: M =	0,075	tonne			
	distance from centre line: D =	0	m			
	cosine power: n =	0				
	shall not be greater than (<=)	10	deg	-0,4	Pass	103,51
	Intermediate values					
	Heel arm amplitude		m	0		
A.749(18) Ch3 - Design criteria applicable to all ships	3.1.2.6: Turn: angle of equilibrium				Pass	
	Turn arm: a v^2 / (R g) h cos^n(phi)					
	constant: a =	0,9996				
	vessel speed: v =	0	kn			
	turn radius, R, as percentage of Lwl	510	%			
	h = KG - mean draft / 2	2,029	m			
	cosine power: n =	0				
	shall not be greater than (<=)	10	deg	-0,4	Pass	103,51
	Intermediate values					
	Heel arm amplitude		m	0		

Resistance – Speed Graph



Power – Speed Graph



SUMMARY

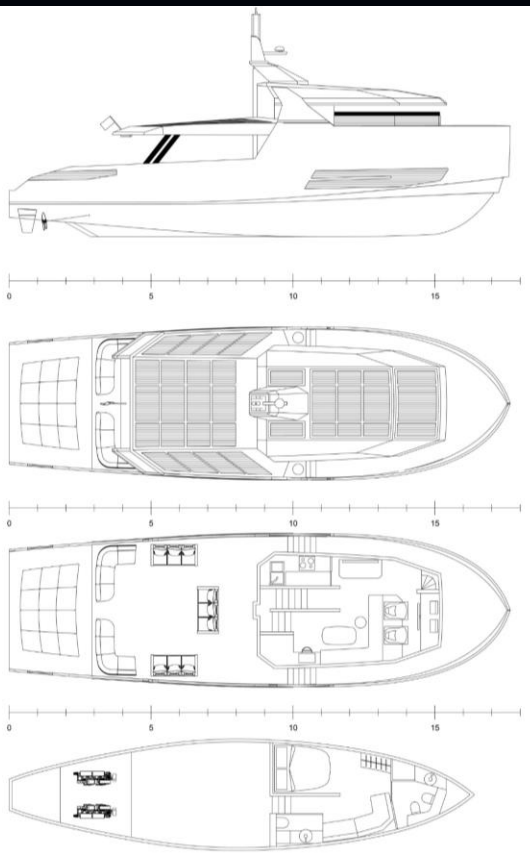
Comparision about main properties of 24 M, 21 M, 18 M

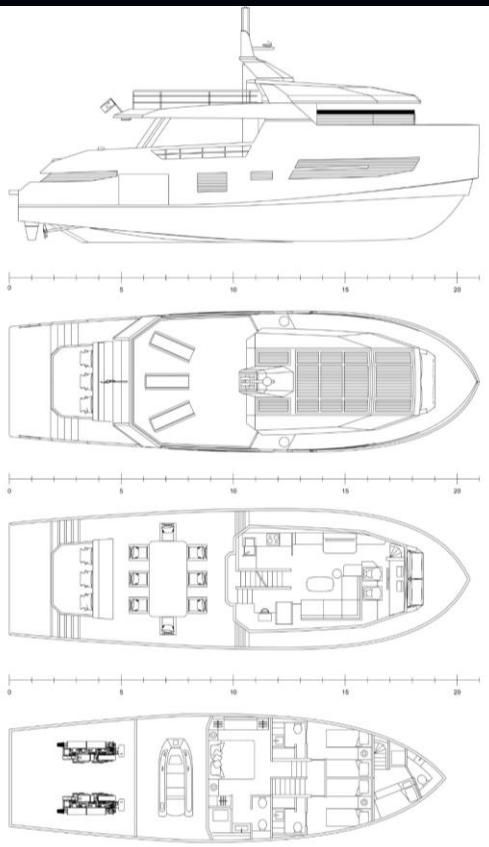
	LENGTH (M)	DISPLACEMENT (M^3)	V_{MAX} (KNOTS)	GUEST - CREW	OPEN DECK AREA (M^2)	CLOSED DECK AREA (M^2)
	18	33	18	2+2	57,9	41,2
	21	48	18	6+2	114,1	80,1
	24	63	18	8+2	142,6	111,7

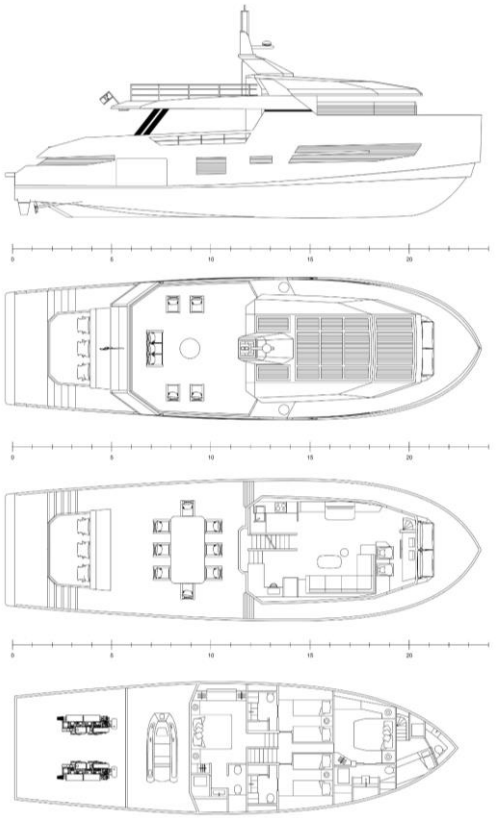
CONCLUSION

Boats of different sizes but with the same concept are designed for different budgets. In order to be preferable in terms of ergonomics and economics, the general layout of the 24 m motor yacht, which is taken as a reference, has been rearranged for 21 meters and 18 meters. A good step has been taken for the accessibility of motoryachts, one of the main objectives.

Comparision Between GA's

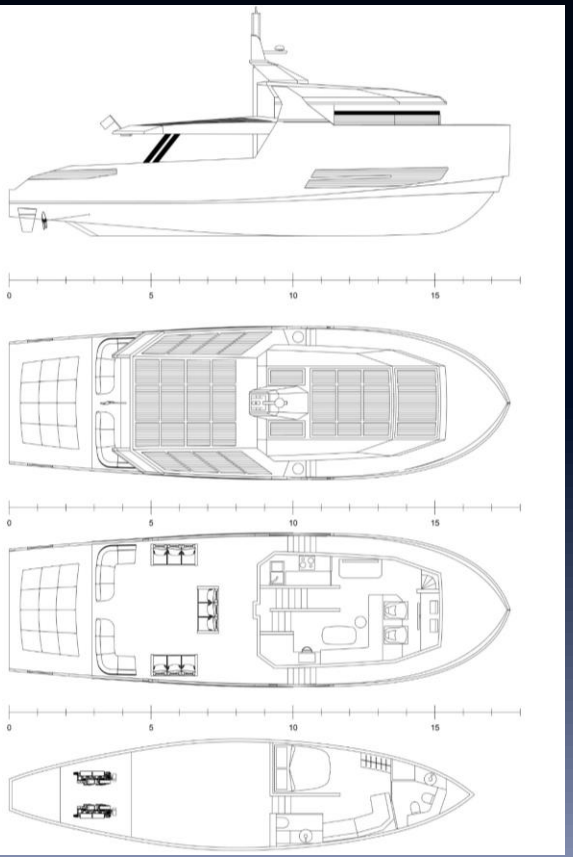
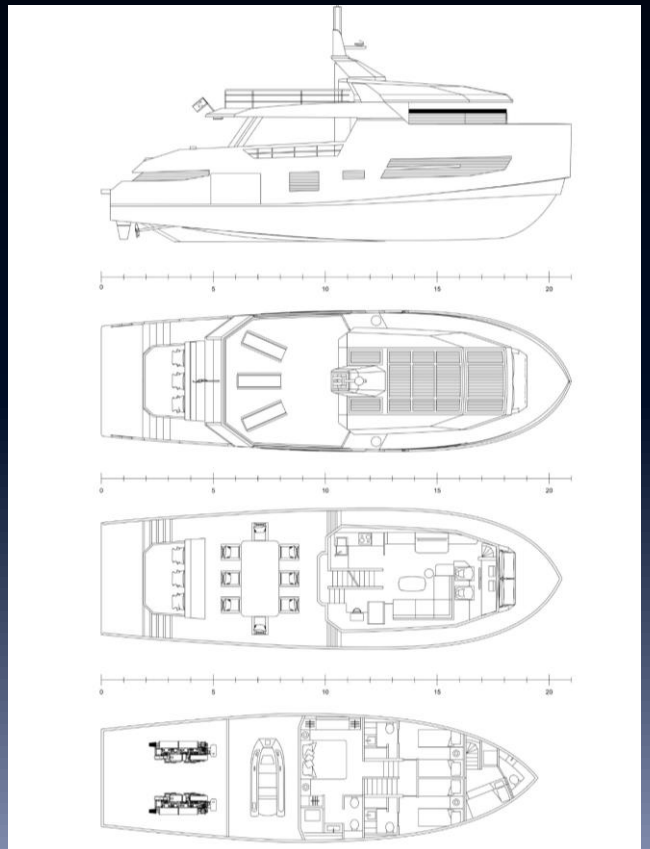
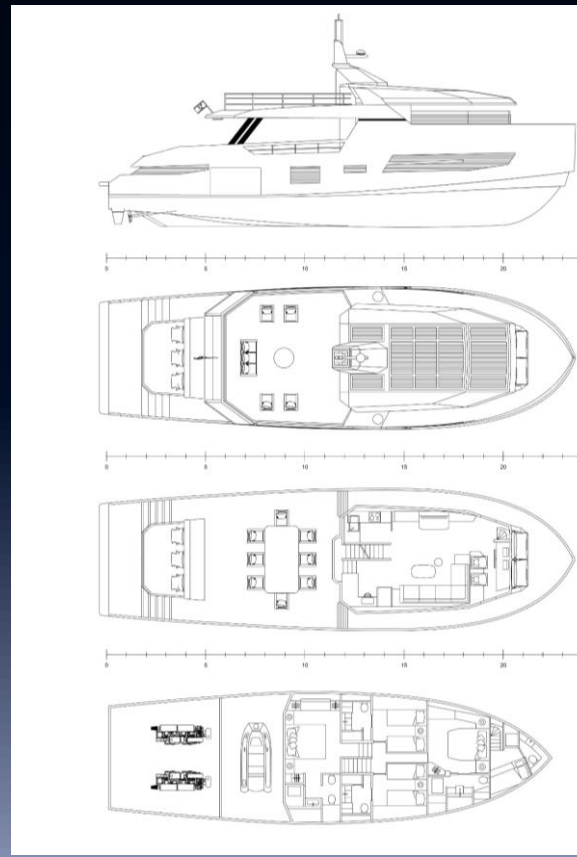






CONCLUSION

Boats of different sizes but with the same concept are designed for different budgets. In order to be preferable in terms of ergonomics and economics, the general layout of the 24 m motor yacht, which is taken as a reference, has been rearranged for 21 meters and 18 meters. A good step has been taken for the accessibility of motoryachts, one of the main objectives.

Thanks For Listening