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Performance Prediction Report – 22m Survey Catamaran

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Contents

1 Introduction

This report provides a summary of the calculations for predicting the performance of the 22m Survey boat considering the survey conditions at 5 knots and below, cruising speed at 10 knots and top speed of about 16 knots.

1.1 Performance Requirements

The performance requirements of the vessel can be summarized as follows:

1. 10 days fuel endurance;
2. Survey at 1-5 knots;
3. Cruising speed of 10 knots;
4. Top speed of about 16 knots.

2 Vessel Characteristics

2.1 Main Particulars

The main particulars of the vessel are as follows:

Length Overall	22.25m
Waterline Length	19.70m
Moulded Beam	7.38m
Moulded Depth	3.35m
Draft Max.	~1.45m

2.2 Weights and Centres

The predicted weights of the vessel are given in Table 1.

ITEM	Displacement	LCG	Deadweight
	[t]	[m] from aft	[t]
Lightship	47.5	8.90	0.0
Full Load	60.8	8.78	13.3

Table 1: load condition breakdown.

The resistance and powering are evaluated for the for the full load condition given above.

2.3 Propulsion

The vessel is fitted with the following propulsion:

Propulsion:	2x FPP ducted propellers
Engines:	2x MAN D2676 LE422, 478kW @ 2100 RPM

The engine power and fuel consumption is published according to the following references conditions:

Intake air temperature Raw water temperature Barometric pressure	25°C 25 °C 1000 mbar

Annexure A gives the performance diagram of the engines for reference purposes.

The engine power output decreases and the fuel consumption increases as the air and water temperatures increase. As Nigeria has tropical weather conditions, the following conditions are considered:

Maximum water temperature: 32 °C

Maximum air temperature of 45 °C

3 Resistance

The total resistance for the vessel is calculated using a combination of empirical relations verified against model tests of a similar hull.

The towing resistance of the survey array has been estimated using drag coefficients for cylinders and cables as provided in Reference [1].

3.1 Bare Hull Resistance

The bare hull resistance was calculated using empirical methods as well as model test data for a similar hull input into NAVCAD [2] software.

The bare hull resistance of the vessel is shown in **Fig. 1**.

At survey speeds, <4 knots, the resistance is very low. From 5 knots the resistance increases significantly up to about 15 knots (the displacement hump) after which the curve flattens off a bit.

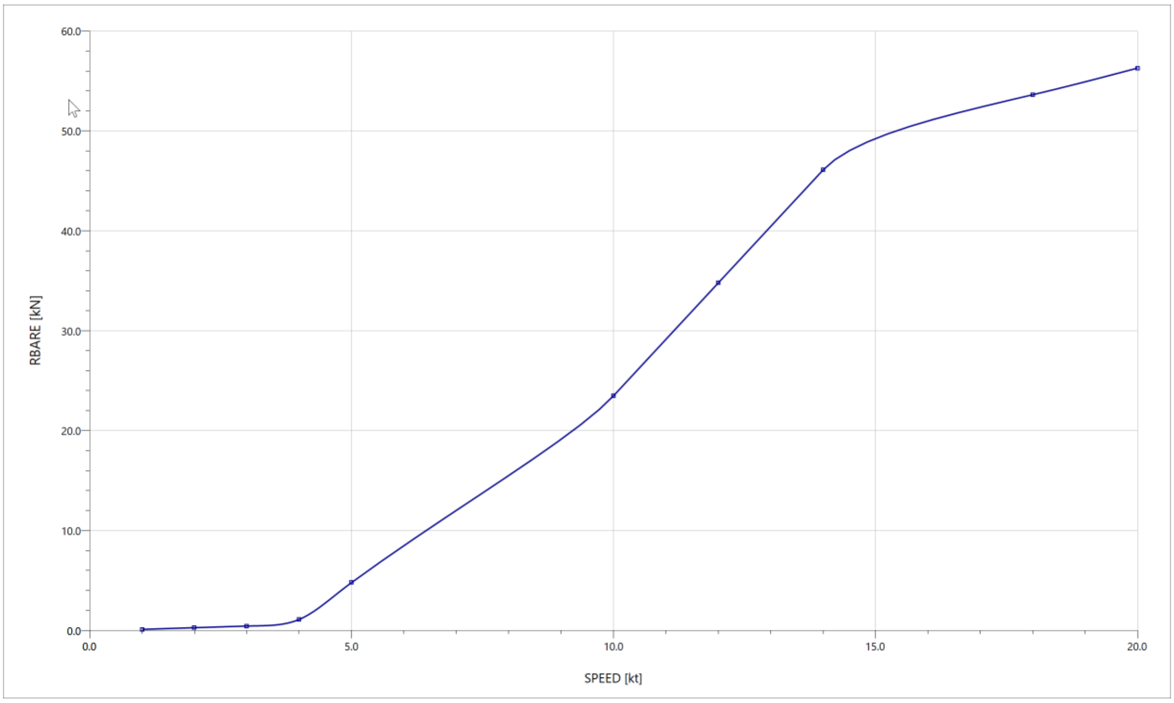


Figure 1: Bare hull resistance for three standard load conditions.

3.2 Total Resistance

The total resistance of the vessel comprises of several different components. The tables in Annexure B give a breakdown of the total resistance of the vessel for various speeds at each load condition. Each of these components is discussed in the sections below.

3.2.1 Appendage Resistance - RAPP

Appendage resistance refers to the resistance from the shafts, stern tube, shaft brackets, rudders and rudder stock. Given this vessel is waterjet powered and has few appendages, it is estimated at 1% of the bare hull resistance.

3.2.2 Air Resistance - RWIND

Air resistance due to the hull and superstructure has been calculated considering head wind conditions of Sea State 2. Air resistance has been calculated considering an air resistance coefficient, $C_{AA} = 0.6$ and considering the frontal areas of the hull and superstructure. This is in line with the Method of Taylor [3] for calculating air resistance for large ships. The air resistance for the vessel is about 7% of the total resistance at 30 knots.

3.2.3 Wave Resistance - RSEA

The trial condition considers Sea State 2, which considers a significant wave height of 0.3m with a period of 6.3s according to the Pierson Moskowitz wave spectrum. For this vessel, this is rather small and has therefore not been considered.

3.2.4 Towing Resistance – RTOWED

At speed up to 5 knots, the resistance of the survey array being towed behind the vessel has been added.

3.2.5 Margins

Finally, a margin has been added to account for unknowns and variations. A margin of 4% of the bare hull resistance is considered to be suitable for final resistance prediction [2].

4 Powering, Propulsion and Hull-Propulsor Interaction

4.1 Engines

The propulsion arrangement of the vessel is shown on the General Arrangement drawing:

TEG-1451-A-080-GENERAL ARRANGEMENT-REV 3

The engine performance characteristics are provided in Annexure A.

4.2 Hull Propulsor Interaction

The hull-propulsor interaction has been calculated using the method of Holtrop [3].

4.3 Propellers

Each engine is coupled to a reverse reduction gearbox and in turn to a ducted fixed pitch propeller.

Reduction ratio:	2.593
Propeller diameter:	750mm
Propeller pitch:	1016mm
No. of blades:	7
Type:	Ducted
Shaft angle:	5 deg.

The estimated propeller curves are given in Figure 2 below.

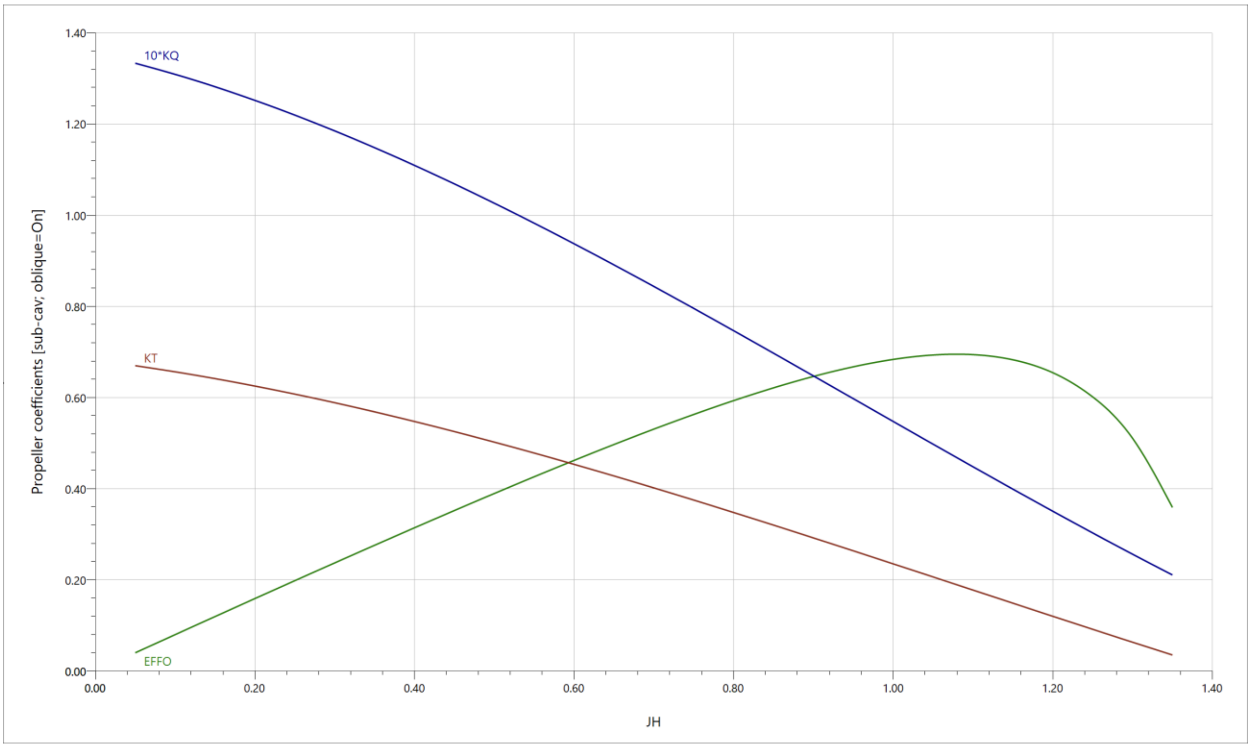


Figure 2: Propeller coefficients

4.4 Gearbox efficiency

Standard gearbox efficiency of 97% has been used for the reverse reduction gearbox.

4.5 Shaft Efficiency

Shaft efficiency has been assumed as 98% - typical for inclined shafts running in stern tubes.

5 Speed Predictions

Based on the resistance data (Annexure B) together with the propeller curves and the various drive train efficiencies the speed prediction has been made. Figure 3 shows the power demand in relation to the engine power:

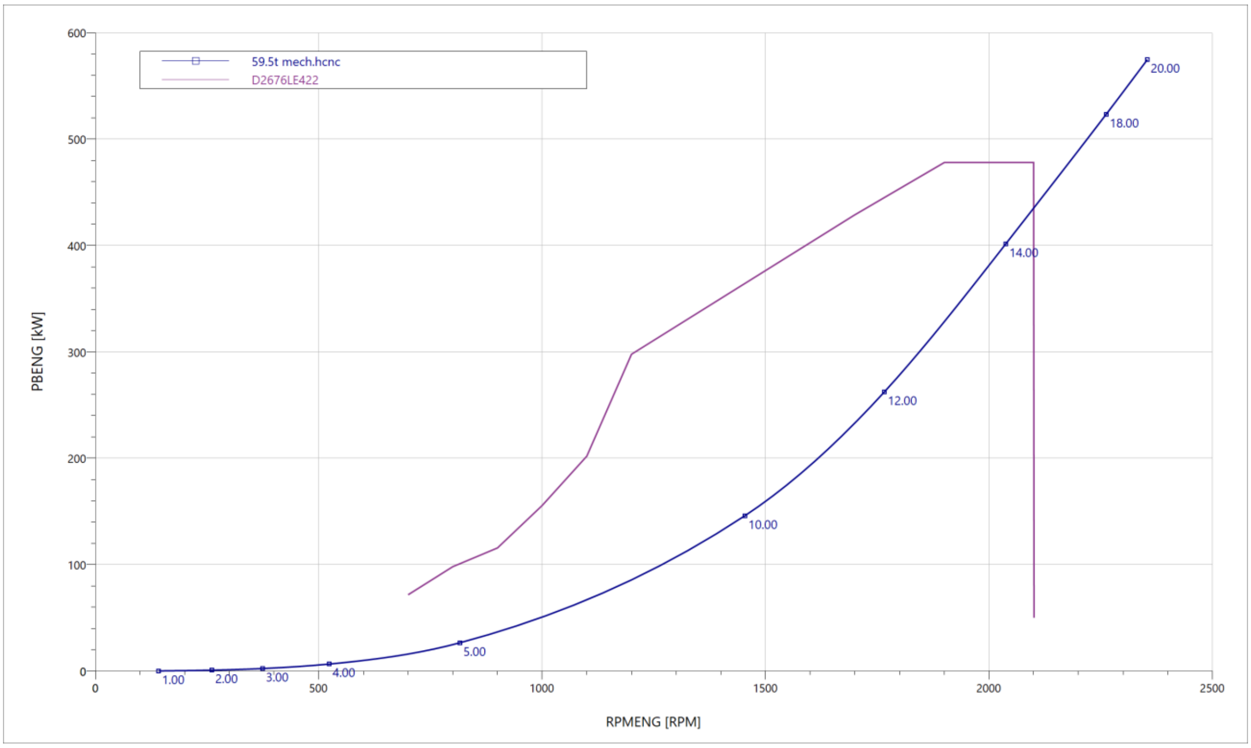


Figure 3: Propeller demand for Full Load Condition

THe top speed for the vessel is around 16 knots. It should be noted that the idle speed of the engine is 700RPM, which means that for speeds less than 4.5 knots, the main engines will be kept at idle and a trolling valve used to reduce the RPM to the propellers.

6 Endurance

The calculated fuel consumption of the engine given in Figure 4. For speeds below 5 knots the fuel consumption is constant according to idle speed fuel consumption.

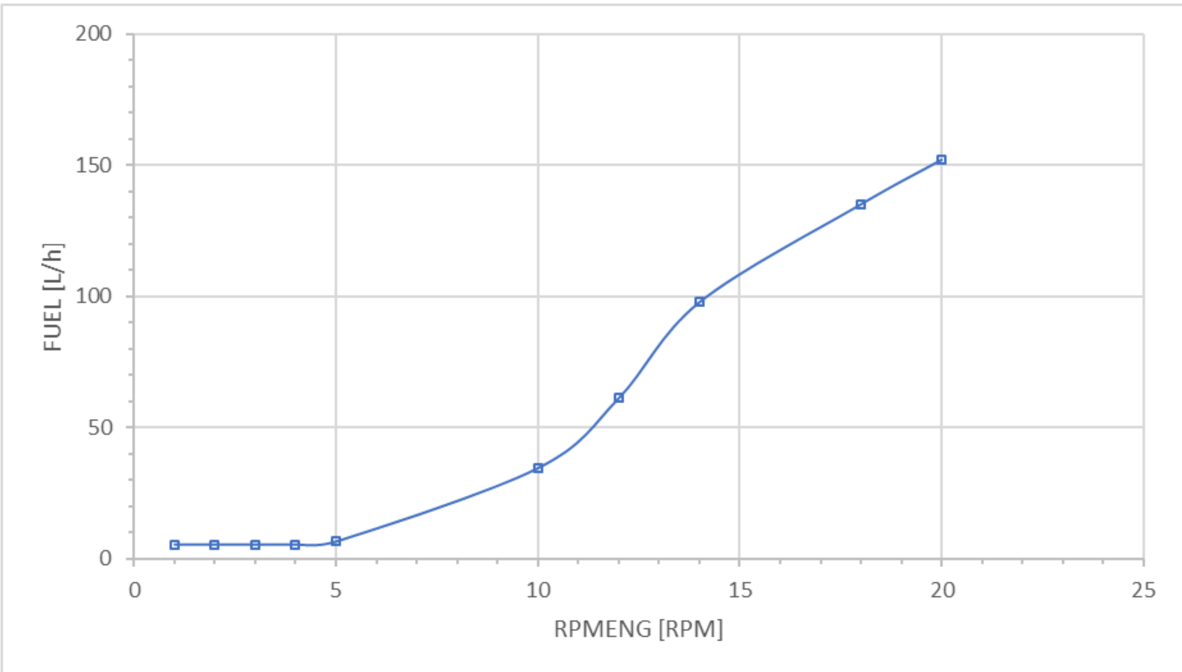


Figure 4: Engine Fuel consumption

Based on this engine fuel consumption, generator fuel consumption as well as the operational profile of the vessel the required fuel capacity for the vessel is given in the table below.

Speed	% Voyage	Hrs / Voyage	Hrs/Year	SFC	No.Engines in use	Fuel [2]	Fuel Twin	Engine Power Demand	Fuel / Voyage	Fuel / Year
				g/kW/h		L/Hr	L/Hr	kW	Liter	Liter
Propulsion Engines										
5.00	70.0%	*168.00*	*4032.00*	250.00	2.00	6.62	13.24	16.00	2224.3	53383.7
10.00	29.6%	*71.04*	*1704.96*	220.00	2.00	34.55	69.10	76.00	4908.9	117812.7
15.00	0.4%	*0.96*	*23.04*	217.00	2.00	120.00	240.00	443.00	230.4	5529.6
									7363.6	**176726.0**
Gensets										
N/a	70.0%	*168.00*	*4032.00*	245.00	2.00	14.10	28.20	45.00	4737.6	113702.4
N/a	30.0%	*72.00*	*1728.00*	245.00	1.00	10.10	10.10	30.00	727.2	17452.8
									5464.8	**131155.2**
								Reserve %	0.05	
								Total	13469.8	307881.2

This matches the fuel tank capacity of the vessel.

7 Conclusions

The performance of the vessel meets the performance requirements of the specification.

8 Bibliography

1. Hoerner, S. " Fluid Dynamic Drag," Published by author, 1965

2. Hydrocomp NAVCAD software, www.hydrocomp.com

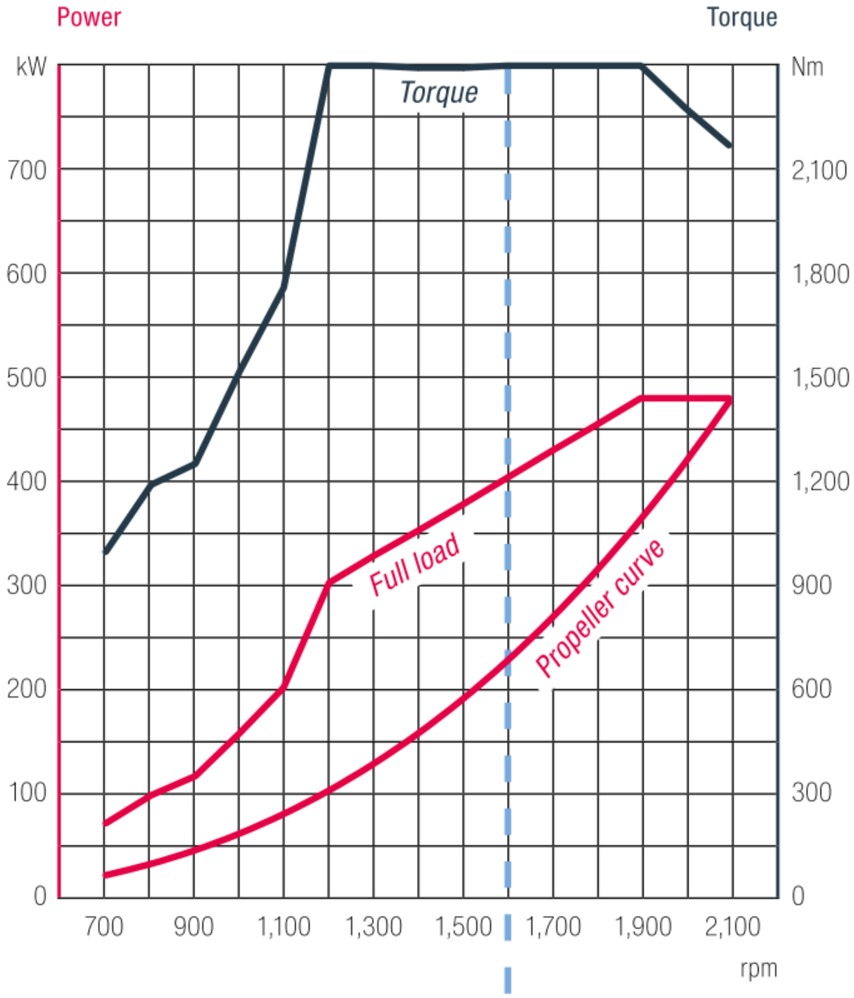
3. Holtrop, J., and Mennen, G.G.J., "A Statistical Power Prediction Method", International Shipbuilding Progress, Vol. 25, October 1978.

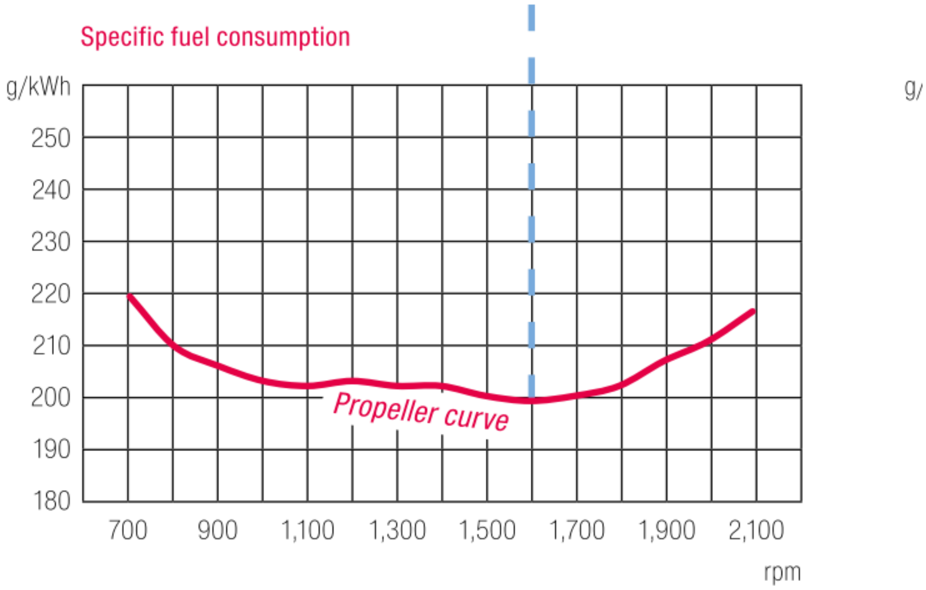
4. D.W. Taylor, "The Speed and Power of Ships", 2nd. Rev., U.S. Maritime Commission, 1943.

5. Holtrop, J., "A Statistical Resistance Prediction Method With a Speed Dependent Form Factor", *Proceedings SMSSH '88*, Varna, Oct 1988.

Annexure A: Performance Diagrams of Engines

D2676 LE 422





Annexure B: Resistance Data

SPEED [kt]	SPEED COEFS		ITTC-78 COEFS						
	FN	FV	RN	CF	[CV/CF]	CR	dCF	CA	CT
1.00	0.036	0.093	8.81e6	0.003067	1.000	0.002912	0.000000	0.000600	0.006579
2.00	0.073	0.187	1.76e7	0.002725	1.000	0.000787	0.000000	0.000600	0.004112
3.00	0.109	0.280	2.64e7	0.002551	1.000	-0.000227	0.000000	0.000600	0.002924
4.00	0.146	0.374	3.52e7	0.002438	1.000	0.001074	0.000000	0.000600	0.004112
5.00	0.182	0.467	4.40e7	0.002355	1.000	0.008525	0.000000	0.000600	0.011479
+ 10.00 +	0.364	0.934	8.81e7	0.002122	1.000	0.011346	0.000000	0.000600	0.014068
12.00	0.437	1.121	1.06e8	0.002067	1.000	0.011804	0.000000	0.000600	0.014470
14.00	0.510	1.307	1.23e8	0.002022	1.000	0.011464	0.000000	0.000600	0.014085
18.00	0.655	1.681	1.59e8	0.001951	1.000	0.007360	0.000000	0.000600	0.009911
20.00	0.728	1.868	1.76e8	0.001922	1.000	0.005905	0.000000	0.000600	0.008427

	RESISTANCE							
SPEED [kt]	RBARE [kN]	RAPP [kN]	RWIND [kN]	RSEAS [kN]	RCHAN [kN]	RTOWED [kN]	RMARGIN [kN]	RTOTAL [kN]
1.00	0.11	0.01	0.00	0.00	0.00	0.13	0.00	0.26
2.00	0.27	0.03	0.01	0.00	0.00	0.53	0.01	0.85
3.00	0.44	0.04	0.02	0.00	0.00	1.19	0.02	1.72
4.00	1.10	0.11	0.04	0.00	0.00	2.12	0.04	3.42
5.00	4.79	0.48	0.06	0.00	0.00	3.32	0.19	8.84
+ 10.00 +	23.49	2.35	0.25	0.00	0.00	0.00	0.94	27.03
12.00	34.80	3.48	0.36	0.00	0.00	0.00	1.39	40.03
14.00	46.10	4.61	0.49	0.00	0.00	0.00	1.84	53.05
18.00	53.63	5.36	0.81	0.00	0.00	0.00	2.15	61.95
20.00	56.29	5.63	1.00	0.00	0.00	0.00	2.25	65.18

	EFFECTIVE POWER		OTHER		
SPEED [kt]	PEBARE [kW]	PETOTAL [kW]	CTLR	CTLT	RBARE/W
1.00	0.1	0.1	0.06153	0.13903	0.00018
2.00	0.3	0.9	0.01662	0.08690	0.00046
3.00	0.7	2.7	-0.00480	0.06179	0.00074
4.00	2.3	7.0	0.02270	0.08690	0.00184
5.00	12.3	22.7	0.18015	0.24259	0.00804
+ 10.00 +	120.9	139.1	0.23976	0.29729	0.03940
12.00	214.8	247.1	0.24944	0.30580	0.05836
14.00	332.0	382.1	0.24226	0.29766	0.07732
18.00	496.6	573.6	0.15555	0.20946	0.08994
20.00	579.2	670.6	0.12478	0.17809	0.09441

Table B1: Full Load Resistance Data

Annexure C: Propulsion Data

	HULL-PROPULSOR				ENGINE				
SPEED [kt]	PETOTAL [kW]	WFT	THD	EFFR	RPMENG [RPM]	PBENG [kW]	FUEL [L/h]	LOADENG [%]	
1.00 !	0.1	0.4845	0.1305	0.9994	142	0.1	0.04	0.0	
2.00	0.9	0.4782	0.1305	0.9994	261	0.8	0.23	0.2	
3.00	2.7	0.4723	0.1305	0.9994	374	2.4	0.66	0.5	
4.00	7.0	0.4685	0.1305	0.9994	523	6.6	1.80	1.4	
5.00	22.7	0.4659	0.1305	0.9994	816	26.6	6.62	5.6	
+ 10.00 +	139.1	0.4587	0.1305	0.9994	1454	146.0	34.55	30.5	
12.00	247.1	0.4571	0.1305	0.9994	1766	262.5	61.15	54.9	
14.00	382.1	0.4558	0.1305	0.9994	2038	401.5	97.71	84.0	
18.00	573.6	0.4537	0.1305	0.9994	2262	523.4	135.01	109.5	
20.00	670.6	0.4529	0.1305	0.9994	2355	574.8	151.95	120.2	
	POWER DELIVERY								
SPEED [kt]	RPMPROP [RPM]	QPROP [kN·m]	QENG [kN·m]	PDPROP [kW]	PSPROP [kW]	PSTOTAL [kW]	PBTOTAL [kW]	TRANSP	
1.00 !	55	0.02	0.01	0.1	0.1	0.3	0.3	568.2	
2.00	101	0.07	0.03	0.8	0.8	1.6	1.6	187.9	
3.00	144	0.15	0.06	2.2	2.3	4.6	4.7	97.6	
4.00	202	0.29	0.11	6.2	6.4	12.7	13.1	46.8	
5.00	315	0.77	0.30	25.3	25.8	51.5	53.1	14.4	
+ 10.00 +	561	2.36	0.91	138.7	141.6	283.1	291.9	5.3	
12.00	681	3.50	1.35	249.6	254.7	509.3	525.1	3.5	
14.00	786	4.64	1.79	381.7	389.5	779.0	803.1	2.7	
18.00	872	5.44	2.10	497.5	507.7	1015.3	1046.7	2.6	
20.00	908	5.74	2.21	546.4	557.5	1115.1	1149.6	2.7	
	EFFICIENCY				THRUST				
SPEED [kt]	EFFO	EFFG	EFFOA	MERIT	THRPROP [kN]	DELTHR [kN]			
1.00 !	0.3097	0.9700	0.5116	0.67126	0.15	0.13			
2.00	0.3401	0.9700	0.5549	0.65925	0.49	0.43			
3.00	0.3593	0.9700	0.5797	0.65123	0.99	0.86			
4.00	0.3452	0.9700	0.5531	0.65713	1.96	1.71			
5.00	0.2768	0.9700	0.4414	0.6749	5.09	4.42			
+ 10.00 +	0.3122	0.9700	0.4911	0.65655	15.55	13.52			
12.00	0.3093	0.9700	0.4852	0.6577	23.02	20.01			
14.00	0.3135	0.9700	0.4905	0.65604	30.51	26.52			
18.00	0.3624	0.9700	0.5650	0.63519	35.62	30.97			
20.00	0.3864	0.9700	0.6014	0.62417	37.48	32.59			

Table C2: Full Load Propulsion Data