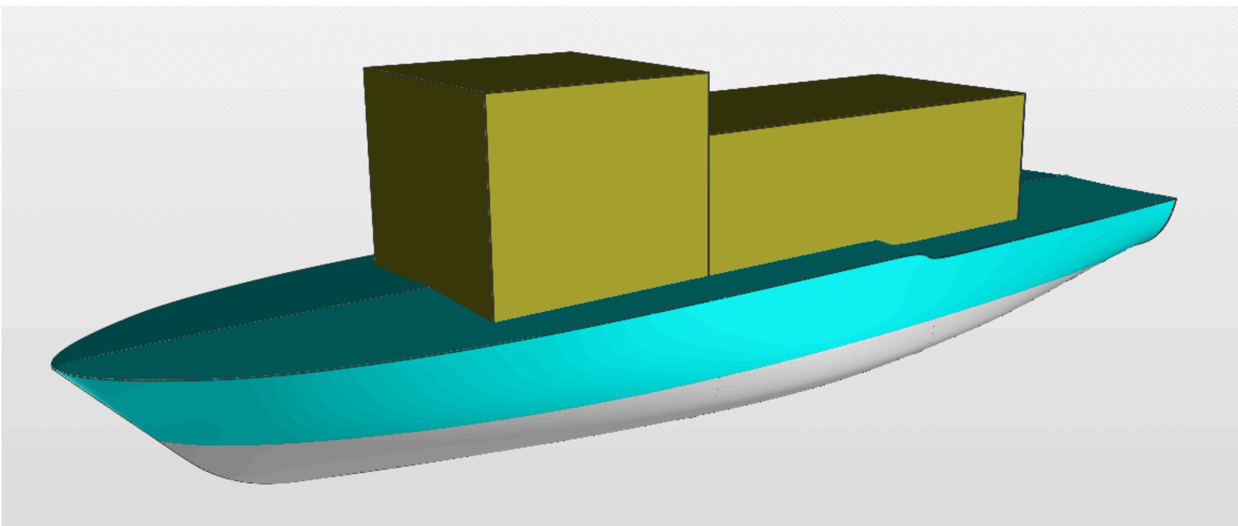
Project Phase 2: Final Design
Fireboat - The Dalmatian



April 18, 2024

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Summary

This report outlines the preliminary design of the Dalmatian, a firefighting and rescue vessel intended to operate on the wildfire prone Okanagan Lake in the interior of British Columbia, Canada. The principal particulars of this vessel are based on similar vessels and iterative design. These values are shown in Table 0 below.

Table 0: Principal Particulars

Particular	Value
Length Overall L (m)	20
Waterline Length (m)	20.358m
Beam (m)	6
Depth (m)	2
Design Draft (m)	1.25
Design Freeboard (m)	0.75
Displaced Volume (m^3)	85
Displacement (t)	85
Lightship (t)	56.2
Deadweight (t)	28.8
Service Speed (kts)	28
Maximum Speed (kts)	32
Block Coefficient	0.5561
Froude Number (@ 28kts)	1.027
Prismatic Coefficient	0.6644
Waterplane Coefficient	0.8339
Midship Coefficient	0.8369
Longitudinal Centre of Buoyancy (m)	9.922
Wetted Surface Area (m^2)	119.2
Installed Power [kW]	2460

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1 Introduction and Background Information

1.1 Vessel Mission Objectives

The type of vessel is a Class A Fireboat (based on Table 1). The name selected for our vessel is The Dalmatian (the DAL).

Table 1: National Fire Protection Association Fireboat Classification [1]

Class A Fireboats	***Class B Fireboats***	***Class C Fireboats***
Length of vessel, 65 ft. and over	Length of vessel, 40 – 65 ft.	Length of vessel, 20 – 40 ft.
Minimum pump capacity, 5,000 GPM	Minimum pump capacity, 2,500 GPM	Minimum pump capacity, 500 GPM
Minimum net pump pressure 150 psi	Minimum net pump pressure, 150 psi	Minimum net pump pressure, 150 psi
Minimum Number of Pumps, 2	Minimum number of pumps, 1	Minimum number of pumps, 1
Minimum number of generators, 2	Minimum number of generators, 1	Minimum number of generators, 0
Minimum number of monitor pipes, 4	Minimum number of monitors, 2	Minimum number of monitors, 1
Minimum crew, 3	Minimum crew, 2	Minimum crew, 2
Minimum # of hose connection: 6 – 1 ½ connections 10 – 2 ½ connection or larger	Minimum # of hose connections: 4 – 1 ½ connections 8 – 2 ½ connections or larger	Minimum number of hose connections: 1 – 2 ½ connection 2 – 1 ½ connections
Fuel capacity, 8 hours	Fuel capacity, 8 hours	Fuel capacity, 4 hours

The aims of this vessel are as follows:
- Suppress lakefront fires with water cannons
- Quickly deploy and recover fire crews and equipment
- Serve as emergency transport for civilians
- Act as a mobile water pump for rural areas
- Perform auxiliary tasks as necessary

The importance of a vessel of this nature was observed during the 2023 Okanagan fires that placed Kelowna and surrounding municipalities into a state of emergency.

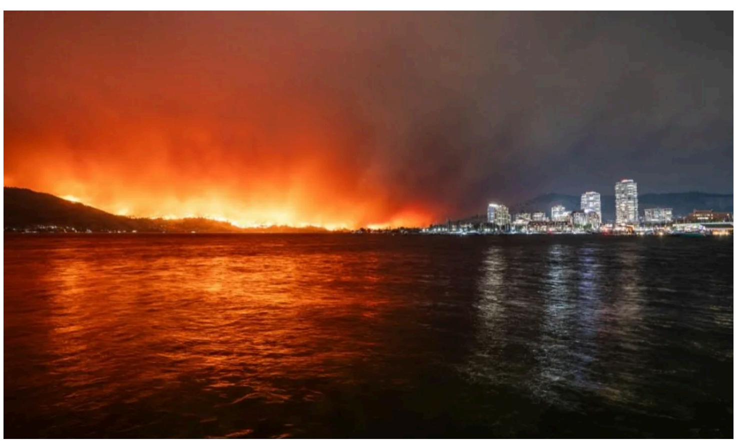

Figure 1: Okanagan Lake - Summer 2023

1.2 Intended Area of Operation

The Dalmatian is a fire suppression vessel designed to operate in interior British Columbia lakes with an intended initial deployment in Okanagan Lake, as seen below.

Figure 2: Okanagan Lake

Okanagan Lake is a large freshwater lake that has a max length of 135km and a max width of 5km. It has a surface area of 351km^2, an average depth of 76m, and sits at an elevation of 342m above sea level. The centre of Okanagan Lake is located at: 49°54'40.0"N 119°30'45.0"W.
Due to the size of the operation region, the speed of the vessel will be vital to promptly respond to emergencies.

The locations of key cities along Okanagan Lake are presented in Table 2. They represent the boundaries of the operation area and operation supply points.

Table 2: Locations of Major Cities Along Lake Okanagan

City	**Longitude, Latitude**
Kelowna	49° 53′ 17″ N, 119° 29′ 44″ W
Vernon	50° 16′ 0″ N, 119° 16′ 18″ W
Penticton	49° 30′ 3″ N, 119° 35′ 38″ W

1.3 Operational Profile

The vessel is intended to primarily operate in the warm summer months when the need for firefighting and emergency transportation is heightened. A typical operation period would be between May and November, or about half the year. For the rest of the year, the vessel would be placed in storage and only accessed in the case of an extended emergency. When in use, the Dalmatian will split its time between firefighting and emergency transportation tasks. The amount of time spent on each will depend on the current fire conditions but on average it is expected that the Dalmatian will fight fires for some portion of time every year. This operation profile is illustrated in Figure 3, where the percentage of each operation represents the amount of time spent relative to other operations over the vessel's lifetime.

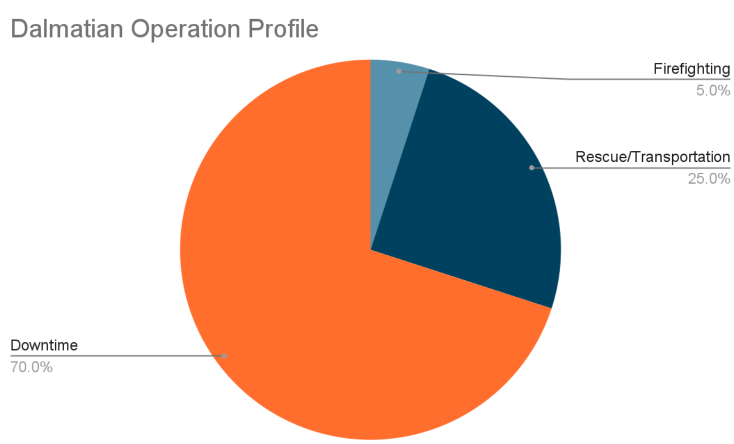

Figure 3: Operation profile of Vessel

1.4 Environmental Conditions

Kelowna and, by proxy, Okanagan Lake have the greatest percentage of "calm" wind observations for any major city in Canada (39% of the time) [5]. These calm winds lead to minimal wave formation on the lake and thus allow for the extended life of marine vessels operating within the area. Historic wind conditions from 1981 to 2010 and averaged by month can be observed in the figure below.

1981 to 2010 Canadian Climate Normals station data

Wind												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Speed (km/h)	4.6	4.7	6.0	6.6	6.7	6.7	6.4	5.3	4.6	4.4	4.1	4.7
Most Frequent Direction	N	N	N	N	S	S	N	N	N	N	N	N
Maximum Hourly Speed (km/h)	56	50	50	56	46	56	54	48	52	56	**56**	46
Date (yyyy/dd)	1974/29	1990/05	2004/05	1968/11	2002/02	1967/03	1997/24	1966/10	1978/15	1963/21	**1962/29**	2001/17
Direction of Maximum Hourly Speed	N	SE	S	SE	SW	N	NW	NW	N	S	SE	SW
Maximum Gust Speed (km/h)	93	74	89	**100**	82	87	83	84	67	76	84	80
Date (yyyy/dd)	1999/29	1990/05	1973/16	**1980/14**	1975/18	1989/24	1998/30	1972/21	1983/01	1991/16	1975/03	1979/14
Direction of Maximum Gust	SE	SE	W	S	N	N	E	S	SW	W	S	N
Days with Winds >= 52 km/h	0.1	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.0	0.1	0.1	0.1
Days with Winds >= 63 km/h	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Figure 4: Historical wind data for Kelowna Airport [5]

Empirical wave data for Okanagan Lake is limited to non-existent. One source of simulated wave data comes from an analysis performed by Eric Morris, a previous Master's student at UBC. They found the maximum wave height on Okanagan Lake near Kelowna to be 1.36 meters with a period of 4 seconds [6].

2.0 Applicable Regulations

The design and operation of fireboats are governed by the National Fire Protection Association's document number 1925. The document outlines the minimum rules and regulations required to be followed by all new and converted marine firefighting vessels. The links to these regulations are seen below.

NFPA 1925: Standard on Marine Fire-Fighting Vessels
https://www.nfpa.org/codes-and-standards/1/9/2/1925?l=374

NFPA 1925: references ABS's Rules for Building and Classing Steel Vessels for Service on Rivers and Intracoastal Waterways
https://ww2.eagle.org/content/dam/eagle/rules-and-guides/current/conventional_ocean_service/4-rules-for-building-and-classing-steel-vessels-for-service-on-rivers-and-intracoastal-waterways-2024/4-river-rules-jan24.pdf

3.0 Design Concept

This section discusses an overview of the design concept and high level requirements.

3.1 Design Requirements

The overall performance requirements of the DAL are tabulated below.

Table 3: Performance Requirements of The Dalmatian

Roles	Fire Suppression, Crew mobility, Transport, Water pump
Crew	10
Passengers	50
Service Area	BC lakes (freshwater)
Service Life	20 years
Top Speed	32 knots (60km/h)

3.2 Payload and Equipment Definition

A preliminary list of payloads is seen below.

- Water cannon(s)
- Firefighting PPE, tanks, clothing (~80lb/person), hoses
- Aerial Tower (Person Crane)
- Equipment Crane
- Secondary RIB
- Fire suppressant
- Medical Equipment: Resuscitators, aspirator, stretchers, med supplies
- Crew: 10x firefighters
- Capacity to carry 50 evacuees.

3.3 Mission-critical Systems and Features

The mission-critical systems and features are as follows:

- Room for crew and civilians
- Ability to pump water from the lake
    - Used to feed water cannons
    - Able to be connected to fire hoses
- Storage room for fire fighting equipment
- Crane to deploy and receive heavy equipment
- Medical center for injured crew and civilians
- Bathroom
- Minimum two means of escape from the main hull to the main weather deck
- Rescue slide
- Transom gate
- Dive platform

3.4 Similar Vessels

There are existing vessels that serve the functions required. These vessels were investigated to inform the design of the Dalmation. The Dalmatian's form will be similar to The Christopher Wheatly, J-2000, and WM Lymon Mackezie as seen below.

Figure 5: Robert Allen, The Christopher Wheatley, [2]

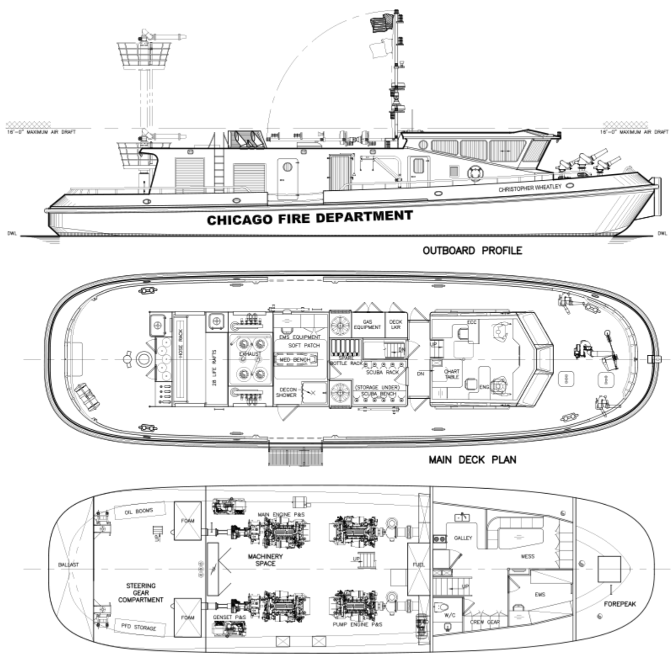

Figure 6: Christopher Wheatley Deck Plan [2]

Figure 7: Robert Allen P-2000 [2]

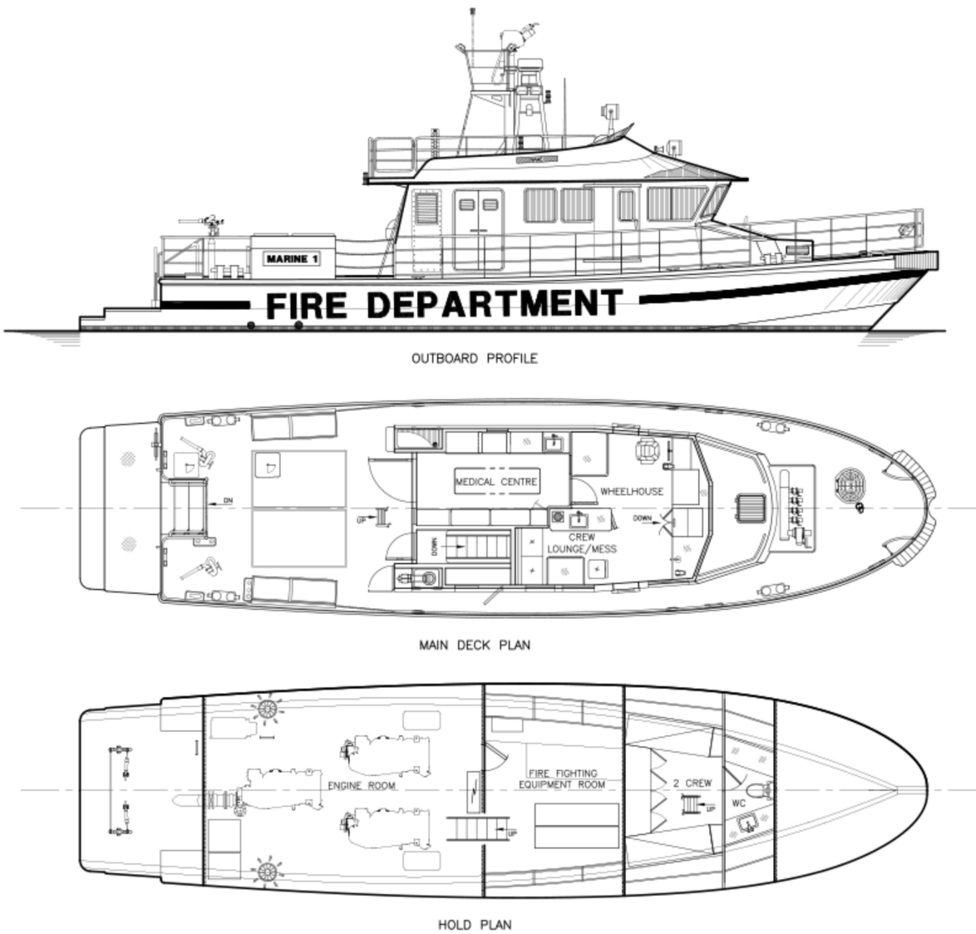

Figure 8: Robert Allen Ranger P-2000 Deck Plan [2]

Figure 9: Russel Brothers LTD, WM Lyon Mackenzie [3]

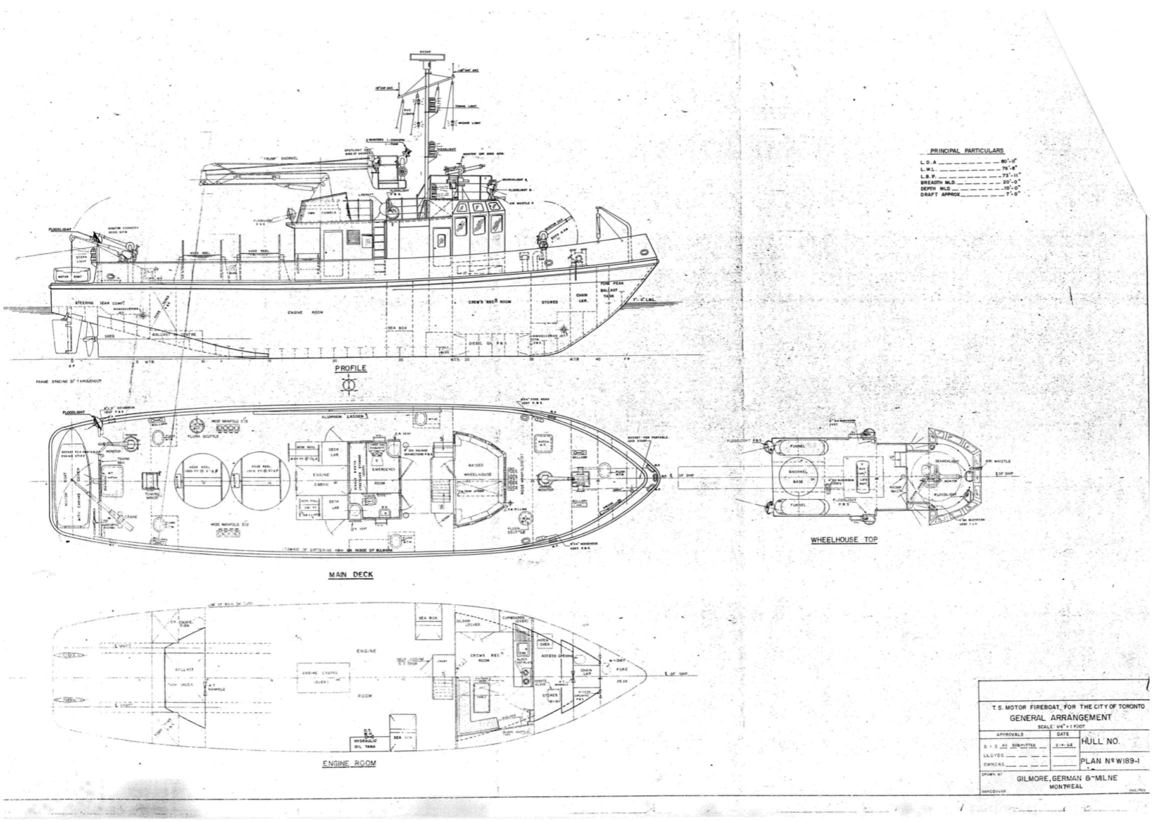

Figure 10: WM Lyon Mackenzie Deck Plan [3]

Seen below in Table 6 is a comparison of familiar vessels.

Table 4: Comparison of In-use Fireboat Dimensions

Class/Name	Shipbuilder	Displacement (t)	Length Overall (m)	Beam (m)	Draft (m)
RAnger J-2000	Robert Allan	N/A	20	5	1.3
RAnger P-2000	Robert Allan	N/A	20.15	6	0.81
RAnger P-2400	Robert Allan	N/A	24.1	6.76	2.13
14M Fire Boat	Walker Marine Design	26	14.45	4.25	1.5
25M Fire Boat	Walker Marine Design	75	25.58	7.9	1.22

From these values, an overall length of 20m, a beam of 6m, a design draft of 1.250m, and a displacement of 75 tonnes are selected as a starting point for the iterative design of the ship.

4. Propulsion

This section discusses potential alternative fuel types, and the final propulsion configuration.

4.1 Fuel Type

In the conceptual design of a new vessel, and with carbon emission goals, it is important to consider alternative fuels. These are compared to Diesel as a baseline fuel. Alternative fuels include Hydrogen, Ammonia, and Liquified Natural Gas. Hydrogen is a tempting option because its combustion only produces water vapor. Production is currently sourced from natural gas, but there is potential to produce net-zero carbon hydrogen by electrolysis with renewable energy. However, to achieve any reasonable energy density, hydrogen must be cryogenically stored, requiring extra machinery, and is difficult to handle due to cryogenic temperatures causing plumbing malfunctions. Ammonia is another option, with the potential for zero-carbon production. Ammonia is toxic and has challenges in spark-ignition and compression-ignition. It is a potential fuel for a future marine vessel. Liquid Natural Gas is another potential fuel, with the potential to reduce emissions by 25%. [7]

However, due to the limited lakeside infrastructure on Lake Okanagan, such as the lack of LNG bunkering facilities, or hydrogen fuel stations, the required cost to install this infrastructure would exceed the resources of the stakeholders, especially as a limited number of vessels could operate on such fuels at the moment. Therefore, diesel fuel is selected to power the vessel, as it is already readily accessible on the lake.

4.2 Final Powering and Propulsion Configuration

Based on the research of similar vessels made by Robert Allan, four propulsion options exist. These are water jets, conventional props, z-drives, or voith drives. Although voith and z-drives provide superior maneuverability, water jets were selected for the Dalmatian. This selection was made to exploit their superior speed and shallow draft. The shallow draft provided by jet propulsion is important for the DAL to closely approach shore without damaging its propellers. High speed is also a valuable asset to quickly deploy crews and respond to fires.

Using water jet propulsion, the RAnger J-2000 was used for comparison as it is a 20m long firefighting vessel [6]. This vessel uses four jet propulsors powered by four diesel 615kW engines. All four motors can be used for propulsion during fast travel, and the central two are used to drive fire pumps when required. This propulsion system is capable of moving the RAnger J-2000 67km/hr, which is over the desired 60km/hr. A similar methodology of propulsion and powering is planned to be used by the DAL.

For electrical power, the RAnger J-2000 requires two 27.5kW diesel gen-sets. The DAL will likely require similar power.

A summary of the planned propulsion and powering is tabulated below.

Table 5: Propulsion and Powering

Propulsion	4x Water Jets
Engines	4x 615kW Diesel
Electrical Generation	2x 27.5kW Diesel Gen-sets
Top Speed	32 knots

5. Structure

This section discusses the vessel structural configuration and structural material.

5.1 Vessel Overview

From researching firefighting vessels, it was determined that their hull shape very closely matches that of a tugboat. Understanding this led to the use of a tug boat parent hull as an initial starting point for a Delftship analysis of the vessel. Adding early superstructure outlines to the hull resulted in the vessel shape seen in Figure 11.

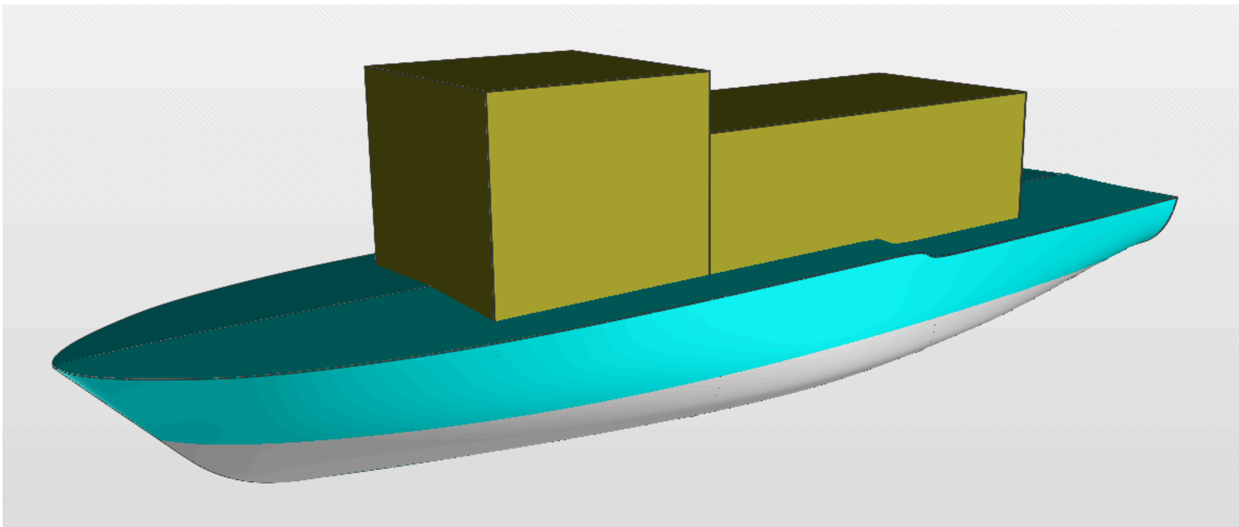

Figure 11: Overall vessel structure and shape

5.2 Structural Material

The ship's hull will be made of 13mm thick steel sheet to meet ABS's "Rules for Building and Classing Steel Vessels for Service on Rivers and Intracoastal Waterways". To save weight the superstructure will be composed of 20mm thick aluminum plate. These materials are assumed constant throughout their respective structures.

6. Weight Estimate

This section discusses weight estimates. The lightship is estimated with two methods. SNAME's method using empirical relations, as well as a mass estimate from DELFTShip and the selected parent hull. Deadweight values are also tabulated, based on known equipment requirements.

6.1 SNAMES Empirical Lightship Estimate

The Dalmatian's weight was initally estimated using empirical calculations from SNAME's Ship Design and Construction [8]. The Lightship is separated into four weight groups.

- Structural (W_s)
- Machinery (W_m)
- Outfit (W_o)
- Weight Margin (W_{margin})

These are calculated using empirically derived formulas based on historical ship data for tugboats, fitted to the Dalmatian's Draft, and block coefficient. Lightship is calculated as the sum of these weight groups

$$W_{LS} = W_S + W_M + W_O + W_{margin}$$

Weight estimates will be based on the block coefficient at 80% depth: C_B\`, using the parent hull values from delftship present a block coefficient of 0.4934.

$$C_B' = C_B + (1 - C_B)\frac{0.8D-T}{3T} = 0.54$$

Computing the structural weight, an empirical formula using Lloyd's equipment numeral $K \approx 0.044$, and empirical weight coefficient $E \approx 400$, from Table 7 for tugs, as well as and block coefficient at 80% of depth C_B' is used. This estimate assumes 100% mild steel construction.

$$W_S = KE^{1.36}[1 + 0.5(C_B' - 0.70)]$$

$$W_S \approx 140\ tonnes$$

Table 6: Empirical Weight coefficients K and E. [SNADES]

TABLE 11.VII Structural Weight Coefficient K (1, 18)

Ship type	*K mean*	*K range*	*Range of E*
Tankers	0.032	±0.003	1500 < E < 40 000
Chemical tankers	0.036	±0.001	1900 < E < 2500
Bulk carriers	0.031	±0.002	3000 < E < 15 000
Container ships	0.036	±0.003	6000 < E < 13 000
Cargo	0.033	±0.004	2000 < E < 7000
Refrigerator ships	0.034	±0.002	4000 < E < 6000
Coasters	0.030	±0.002	1000 < E < 2000
Offshore supply	0.045	±0.005	800 < E < 1300
Tugs	0.044	±0.002	350 < E < 450
Fishing trawlers	0.041	±0.001	250 < E < 1300
Research vessels	0.045	±0.002	1350 < E < 1500
RO-RO ferries	0.031	±0.006	2000 < E < 5000
Passenger ships	0.038	±0.001	5000 < E < 15 000
Frigates/corvettes	0.023		

Weight for the machinery is based on the RAnger 2000, 4x MTU Series 60 main engines, 4x Hamilton Model HJ403 waterjets, and 2x Onan diesel gen-sets. These weights are tabulated in Table 8.

Table 7: Machinery Weight Estimation

Machine	Unit Weight (t)	Qty	Total Weight (t)
MTU S60	1.941	4	7.764
HJ403	0.638	4	2.552
Onan Generator	0.533	2	1.066
TOTAL			11.382

The outfit weight includes the remainder of the lightship weight. This includes the electrical plant, auxiliary systems, HVAC, joiner work, furniture, electronics, paint, etc. Using Figure 11, the outfit weight can be estimated. This figure does not include tugboats, nor does it have data for boats with an LBP of 20m. Approximating $C_o \approx 0.20$, this model estimates an outfit weight.

$$W_o = C_o LB$$
$$W_o \approx 24\ tonnes$$

This value seems high, given our current displacement at draft constraint of ~80 tonnes.

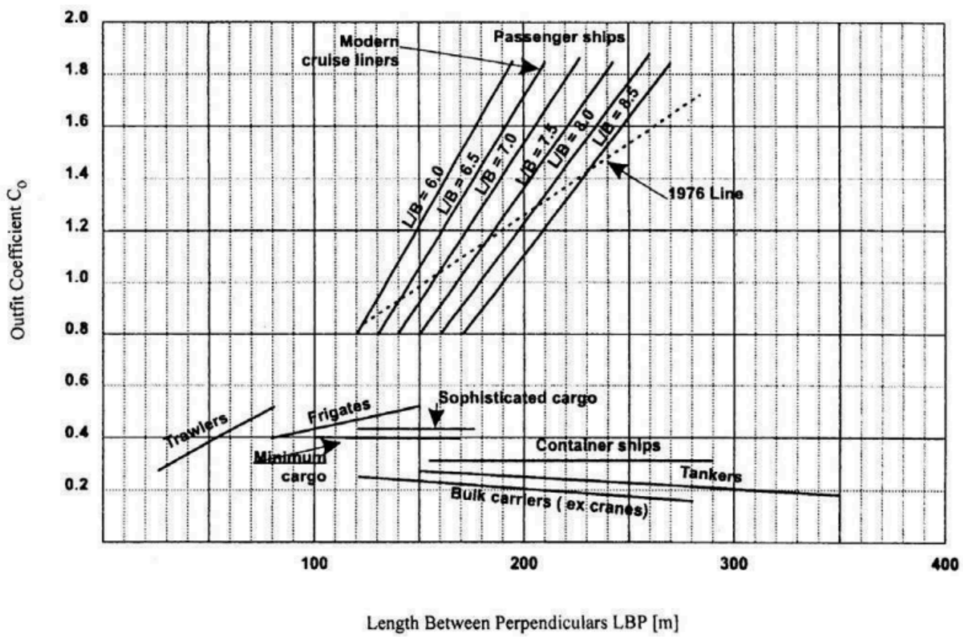

Figure 12: Outfit weight coefficient graph

The lightship estimates are summarized in Table 9

Table 8: Lightship Weights

Lightship Weights	
Ws	140.1825402
Wm	11.382
Wo	24
Total	175.5645402
+5% margin	184.3427672

This lightship value is much higher than similar vessels researched. It is possible that the block coefficient used in the parent hull is not representative of a tugboat and could be the reason for the discrepancy. More accurate values for the lightship can be calculated by summing the weight of individual components and using Delftship to give proper hull tonnage values.

6.2 Delftship Parent Hull Lightship Estimate

Analyzing the ships structure in Delftship yielded the lightship weight estimates seen below in Table 10.

Table 9: Lightship weight estimates from Delftship

The following layer properties are calculated for both sides of the ship

Location	Area	Thickness	Weight	LCG	TCG	VCG
	m^2	m	t	m	m	m
Hull	370.18	0.013	36.324	9.460	0.000 (CL)	1.751
Super Stucture	368.00	0.020	19.872	10.922	0.000 (CL)	4.170
Total	**738.18**		**56.196**	**9.977**	**0.000 (CL)**	**2.606**

Adding onto these structure weights an estimated 6.56 tons for engines, the full lightship value is found as 62.761 tons. These values more closely resemble the weights of similar sized fireboats.

6.3 Deadweight Estimate

To calculate the deadweight estimate, the list of payloads, and their masses must be summed. The fuel, potable water, and Fi-Fi foam tank capacities are taken from the RAnger 2000. The boat is expected to be used as a day-use vessel, so provisions for only one day are considered. Using the estimates from [8].

Table 10: Full Weight Estimates

Item	Tonnage	VCG (m above keel)	LCG (m forward of aft perp)
Hull	36.324	1.751	9.46
Superstructure	19.872	4.17	10.922
Engines	6.565	1.433	5.12
Fuel	3.72	0.765	9.947
Propulsors	2.205	1.67	1.185
Gensets	1.004	1.302	10.002
Crew Quarters	0.633	1.453	15.664
Equip + Med	0.79	3.7	8
Wheelhouse Interior	0.547	4.2	14
Potable Water	0.189	1.185	11.994
Foam	0.809	1.185	9.502
Storage	0.108	1.827	9.993
Ballast	2.547	0.135	12.016
Aerial Tower	1.5	5	10
Equipment Crane	0.55	2.4	0.5
Fore 2000 GPM monitor	0.028	2.4	18
Aft 2000 GPM monitor	0.028	2.4	1

Aerial 2000 GPM Monitor	0.028	5	10
Rigid Inflatable Boat (RIB)	0.641	2.4	2
Crew	1.7	N/A	N/A
Provisions	0.1	N/A	N/A
Fire Fighting PPE	0.036	N/A	N/A
Passengers	5	N/A	N/A
TOTAL	**84.924**	**2.145557287**	**8.558686461**

6.4 Weight Summary

Summarizing lightship and deadship weights, the total weight of the Dalmatian is obtained.

Table 11: Vessel tonnage summary

Weight	tonnes
Lightship	62.761
Deadship	22.163
TOTAL	**84.924**
LCG (m FWD app)	8.56
VCG (KG, m)	2.15

This value is much closer to similar sized fire fighting vessels and was used for the remainder of the analysis and report.

7.0 Hull Form

The hull form was informed by existing fire boats currently in service. Inspiration was drawn from the William Lyon Mackenzie, a modified tugboat. As such, it was decided to use a modified tugboat parent hull. Additionally, a shallow draft of 1.25m was prioritized to allow the vessel to enter shallow waters to fight onshore fires.

7.1 Preliminary Principal Hull Dimensions and Form Coefficients

Based on similar vessels (see section 3.4), initial values of length, beam, depth, draft, and displacement were estimated, and ranges of coefficients of fineness were estimated between estimates for that of a tugboat and a yacht using table 13.

Table 12: Preliminary Hull Dimensions and Form Coefficients

Particular	**Value**
Length L (m)	20
Beam B (m)	6
Depth (m)	2
Draft (m)	1.25
Displacement (t)	75
Block Coefficient	0.4937
Prismatic Coefficient	0.6263
Midship Area Coefficient	0.7881

Table 13: Typical Values of Coefficients of Fineness

Type of Vessel	**Block Coefficient**	**Prismatic Coefficient**	**Midship Area Coefficient**
Crude oil carrier	0.82–0.86	0.82–0.90	0.98–0.99
Product carrier	0.78–0.83	0.80–0.85	0.96–0.98
Dry bulk carrier	0.75–0.84	0.76–0.85	0.97–0.98
Cargo ship	0.60–0.75	0.61–0.76	0.97–0.98
Passenger ship	0.58–0.62	0.60–0.67	0.90–0.95
Container ship	0.60–0.64	0.60–0.68	0.97–0.98
Ferries	0.55–0.60	0.62–0.68	0.90–0.95
Frigate	0.45–0.48	0.60–0.64	0.75–0.78
Tug	0.54–0.58	0.62–0.64	0.90–0.92
Yacht	0.15–0.20	0.50–0.54	0.30–0.35
Icebreaker	0.60–0.70		

7.2 Final Design Values

The tugboat parent hull was selected from the DELFTship database and was created by M. van Engeland. This hull was scaled to a length of 20m, a beam of 6m, and a draft of 1.25m as previously discussed.

The ship's finalized dimensions and hull form coefficients are tabulated below, with graphic renderings shown in figures to 12 to 14. with more information seen in the hydrostatic report in the Appendix.

Table 14: Finalized Vessel Particulars

Particular	**Value**
Length Overall L (m)	20
Waterline Length (m)	20.358m
Beam (m)	6m
Depth (m)	2
Design Draft (m)	1.25
Design Freeboard (m)	0.75
Displaced Volume (m^3)	85
Displacement (t)	85
Lightship (t)	56.2
Deadweight (t)	28.8
Service Speed (kts)	28
Maximum Speed (kts)	32
Block Coefficient	0.5561
Froude Number (@ 28kts)	1.027
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Longitudinal Centre of Buoyancy (m)	9.922
Wetted Surface Area (m^2)	119.2

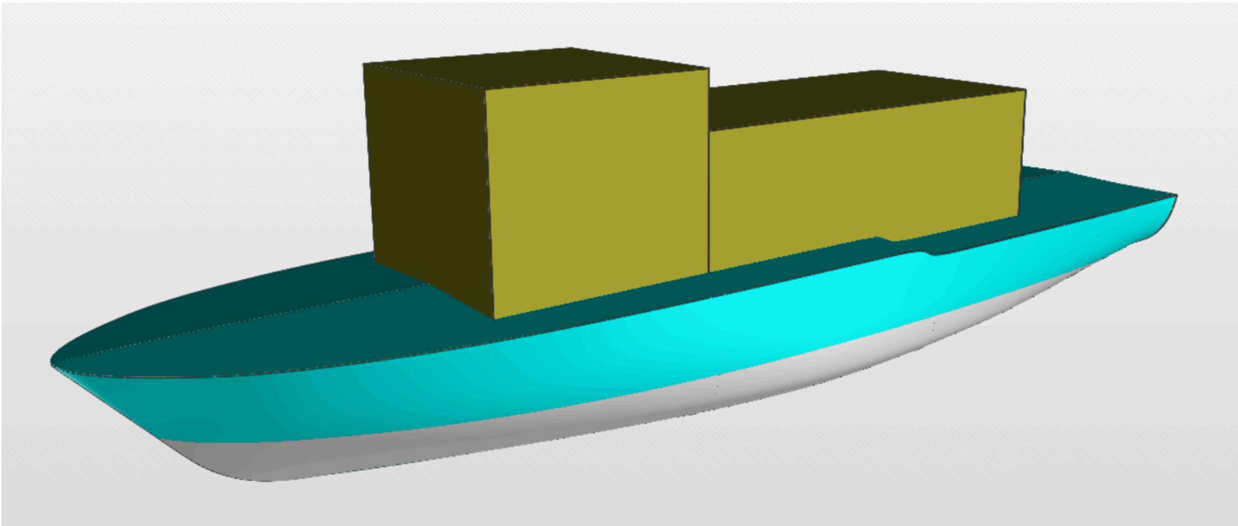


Figure 13: Isometric View of hull

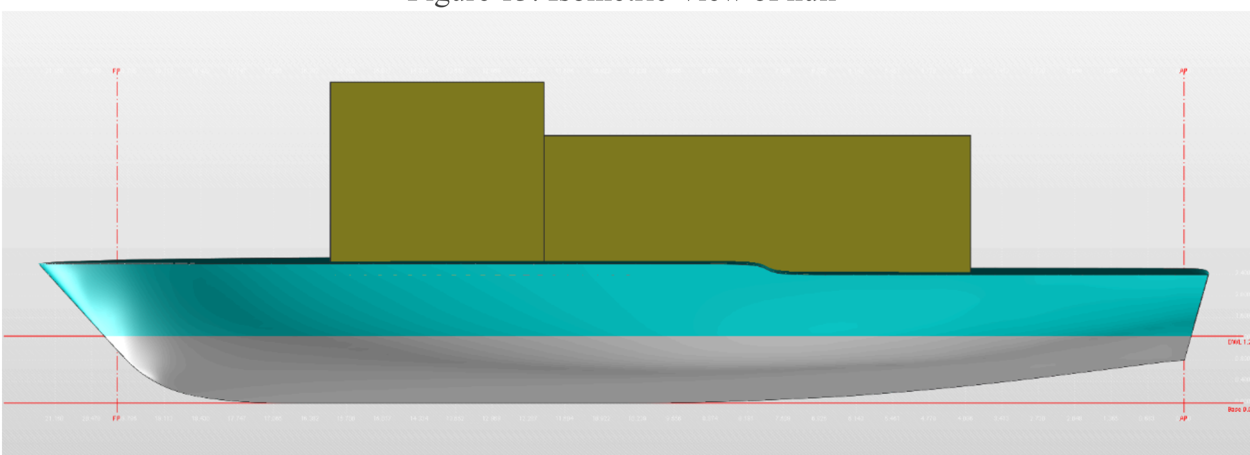


Figure 14: Side view of Hull

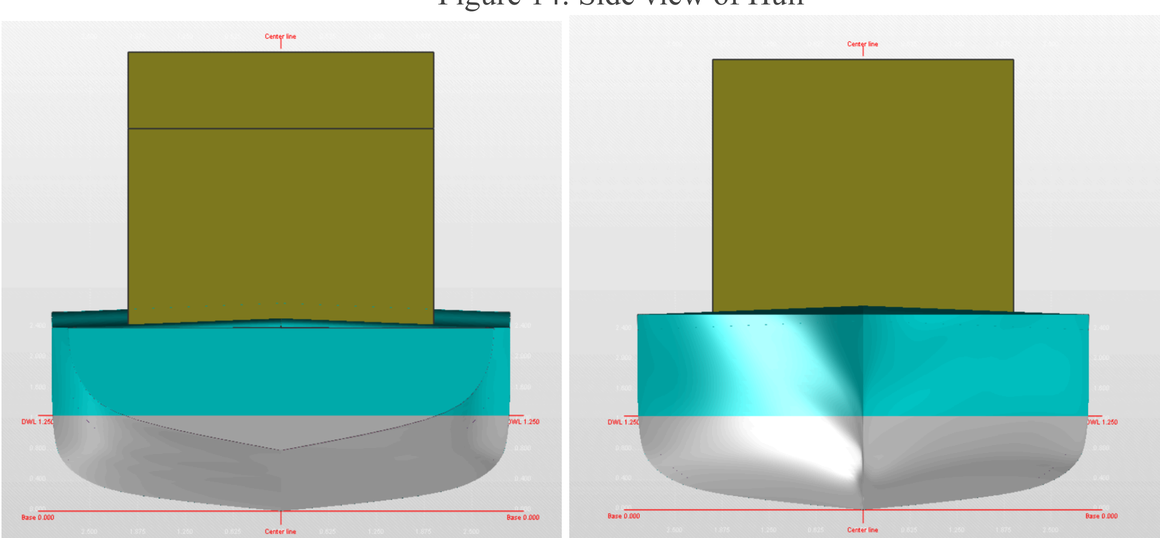


Figure 15: Fore and Aft view of Hull

7.3 Sectional Areas Curve

The sectional areas curve at the design draft of 1.25m was generated in DELFTship. It is shown in Figure 15.

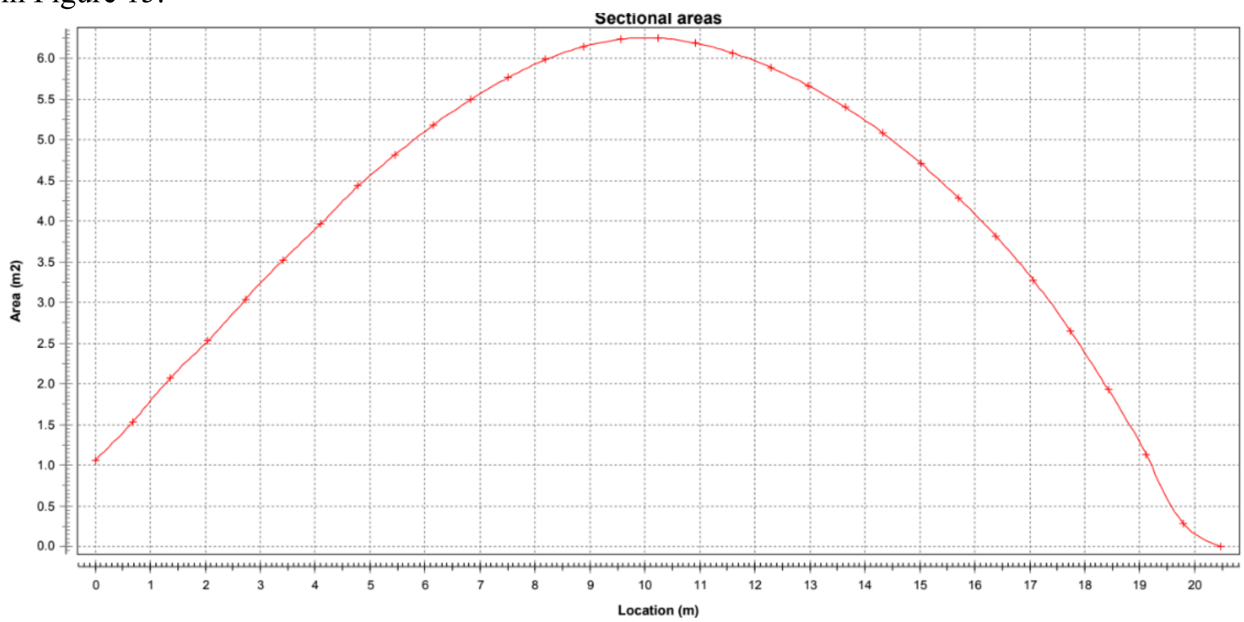


Figure 15: Curve of Areas

7.4 Hydrostatics

The curves of form were generated in DELFTship. They are shown in Figure 16, and the Cross Curves of stability are shown in Figure 17. These curves can be used to determine the change in draft as well the change in trim and heel when adding, removing, or relocating weights. A more detailed hydrostatics report is included in the Appendix.

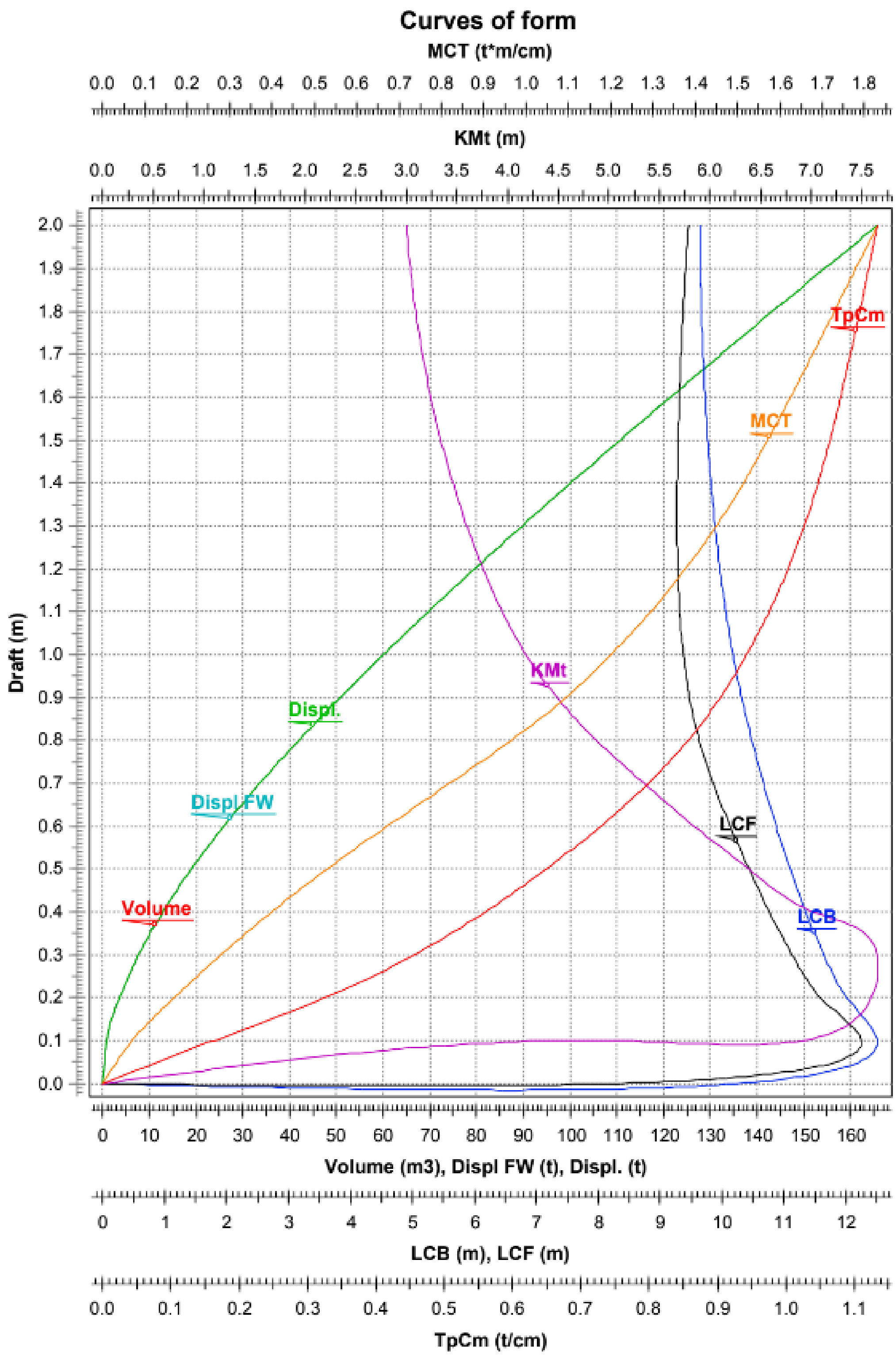


Figure 17: Curves of Form

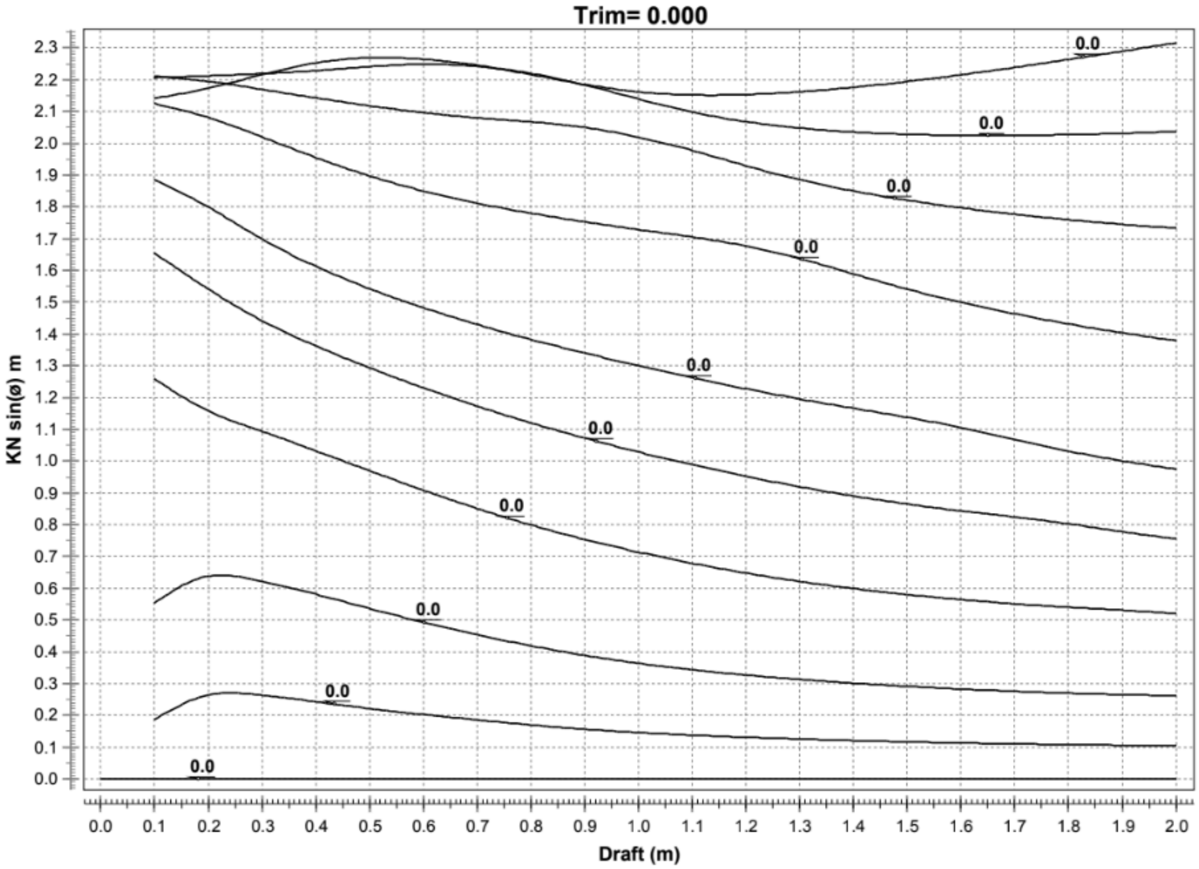


Figure 18: Cross Curves of Stability

7.3 Line Plans

The line plans of this hull are seen below. A large version of this figure is seen in the Appendix.

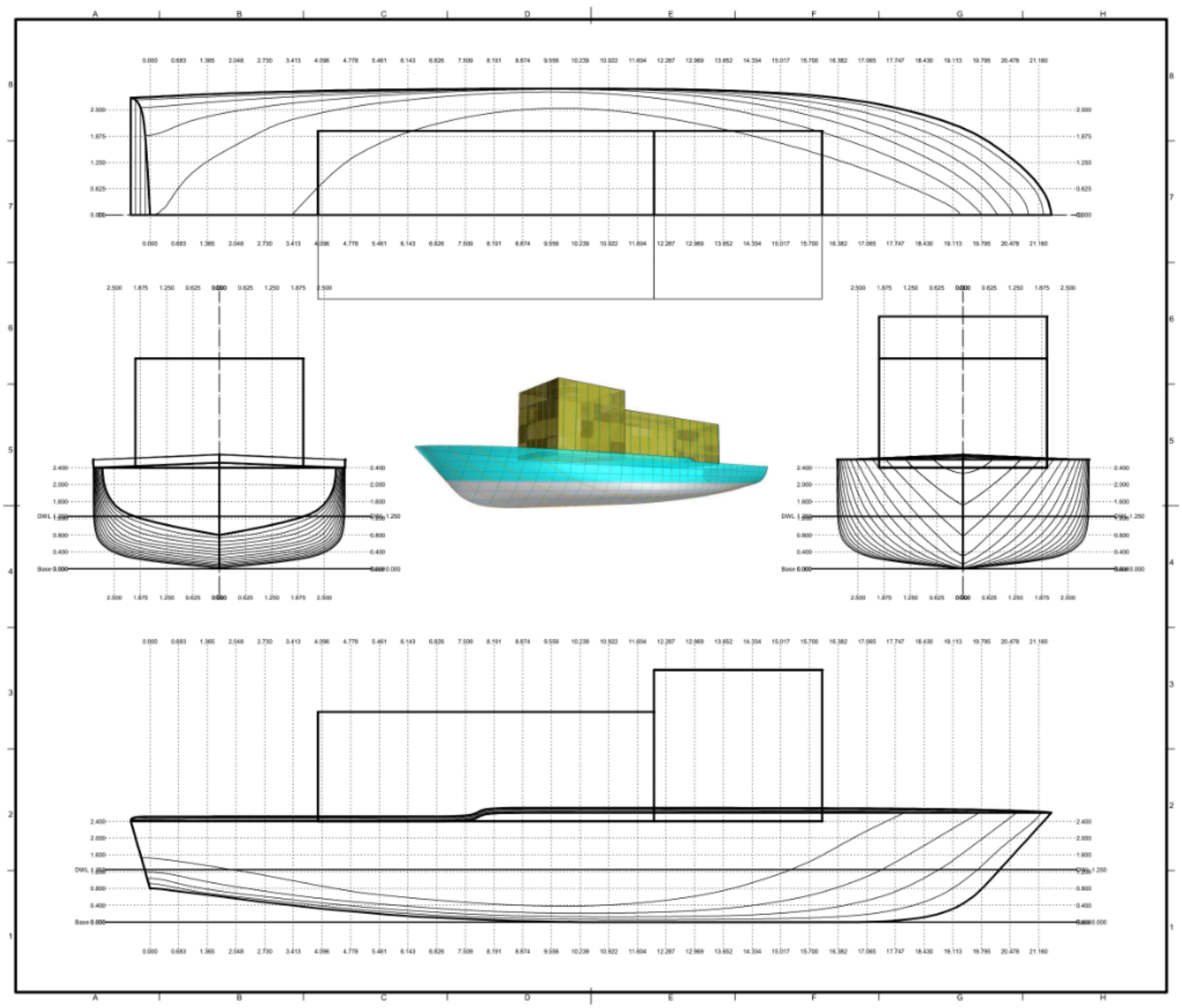


Figure 19: The Dalmatian Line Plans

7.5 Bonjean Plots

The bonjean plot values can be observed in the Appendix. Bonjean curve plots were not generated, but plot values are available in the Appendix. According to the Delftship user manual, Bonjean curves are mostly obsolete [12].

7.6 Resistance

The hydrodynamic resistance as a function of speed is plotted in DELFTShip.

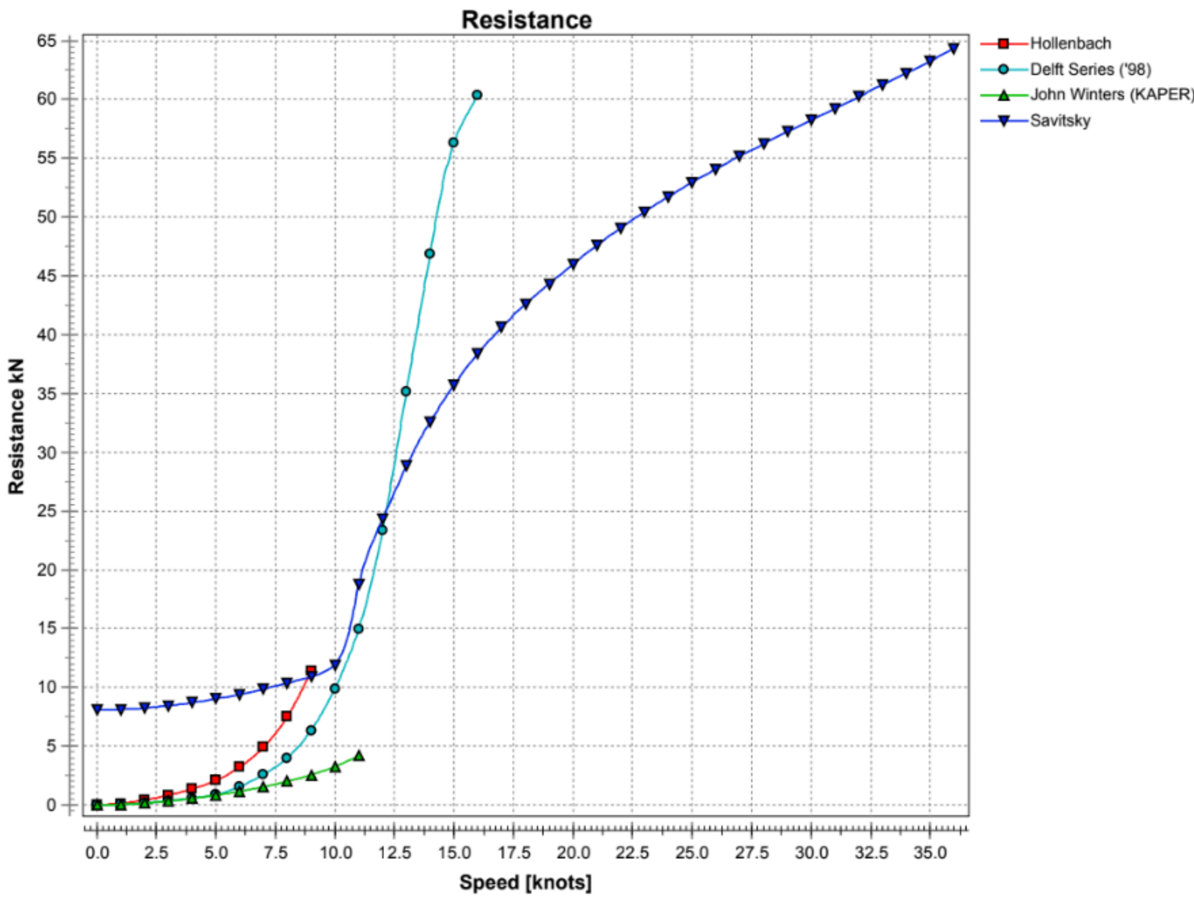


Figure 20: Hydrodynamic Resistance

8. Stability

The stability of the Dalmatian is compared against IMO MSC.267(85), the international code on intact stability, Part A, sections 2.2 - 2.3.

8.1 Floodable Lengths

The floodable length plot is shown in figure 20. Tabulated values are available in the Appendix. Examining the plot, the minimum floodable length occurs at the aft perpendicular, with a length of 4.25m moving forward from this position, the floodable length increases to 10.5m. These calculations assume a permeability of 0.95

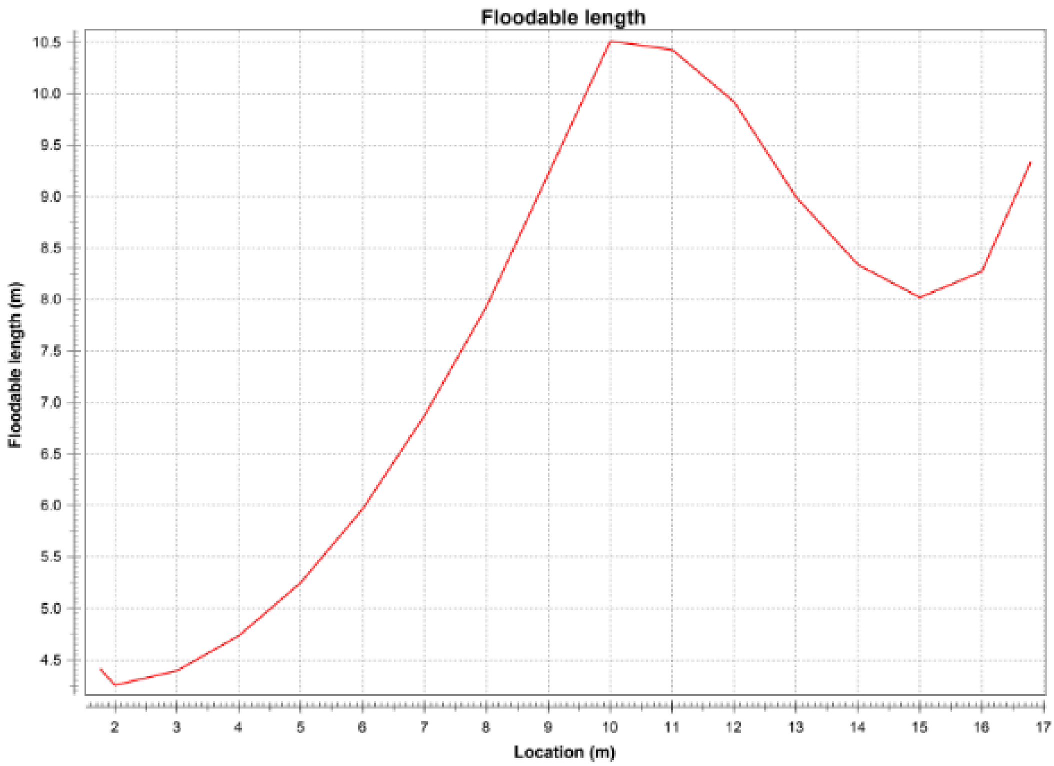


Figure 21: Floodable Length

8.2 Wind Heeling Moment

The wind heeling moment due to steady wind, as well as gusts, is calculated and superimposed on the stability curve in figure 23. The heeling moment is calculated using the wind silhouette (Figure 22). A more detailed report is available in the Appendix.

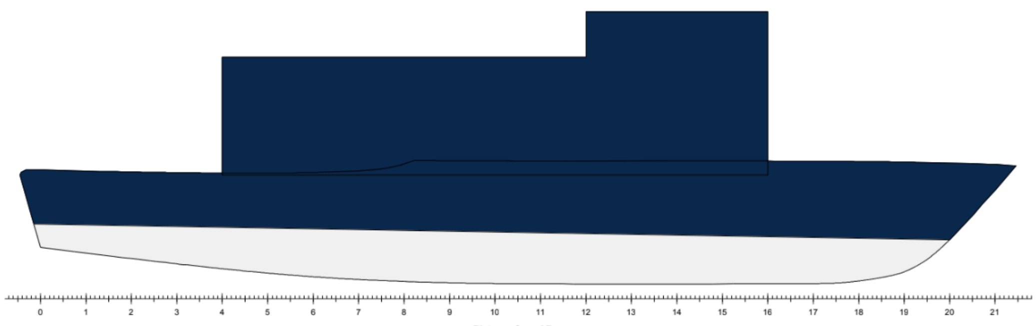


Figure 22: Wind Silhouette

Table 15: Wind Heeling Moment Parameters

Wind Speed	50.54 kn
Wind Pressure	51.37 kg/m^2
Wind Area	66.26 m^2
Steady Wind Lever	0.105 m
Wind Gust Lever	0.157 m

8.3 Stability Curve

The stability curve is plotted below. The vessel is seen to be stable up to a heeling angle of 60 degrees. According to the DELFTship stability report, the Dalmatian complies with all criterion set out by IMO MSC.267(85). The detailed criterion as well as the attained vs required values are available in the Appendix.

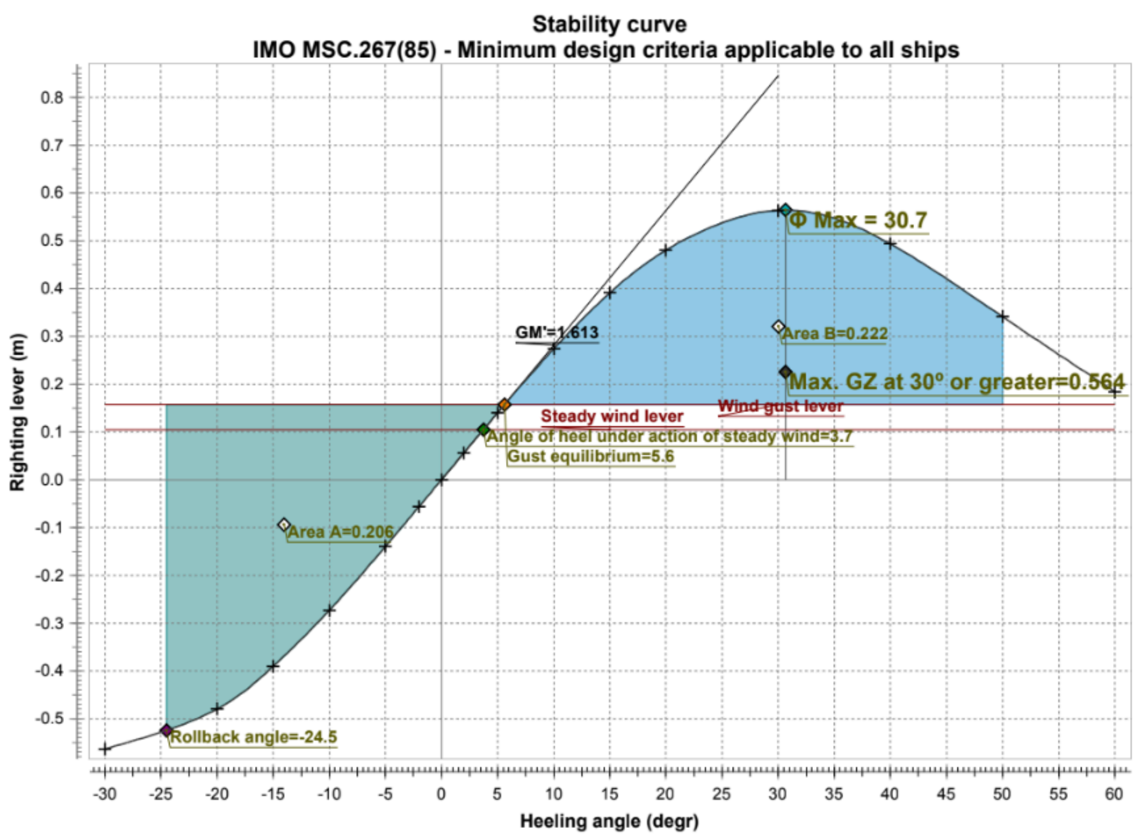


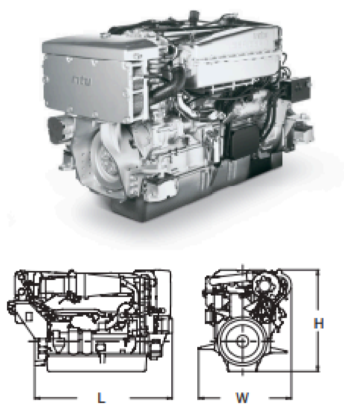
Figure 23: Stability Curve

9. Machinery Selection

Based on the previously outlined requirements, diesel engines, water-jet drives, and electrical generators are selected, to achieve a service speed of 28 knots, and top speed of 32 knots. Diesel machinery is selected to match the available infrastructure on Okanagan lake.

9.1 Diesel Engine

To match engine requirements, 4x Rolls Royce Diesel Engine MTU S60 are selected with a rated power up to 615kW, and a mass of 1841 kg each.



Engine	Dimensions (LxWxH) mm (in)	Mass, dry kg (lbs)
S60	1842x1035x1160 (72.5x40.7x45.7)	1630 (3593)
Engine with Marine gearbox	Dimensions (L_1xWxH_1) mm (in)	Mass, dry kg (lbs)
MG 5114 A	2036x1035x1170 (80.2x40.7x46.1)	1941 (4279)

Typical applications: Fast yachts, fast patrolboats, police craft

Figure 24: Rolls Royce MTU S60

9.2 Water-jet Drive

To match the propulsion requirements, 4x HamiltonJet HJ403 Water-Jet Drive is selected, with a max power output of 900kW, and mass of 638 kg each.

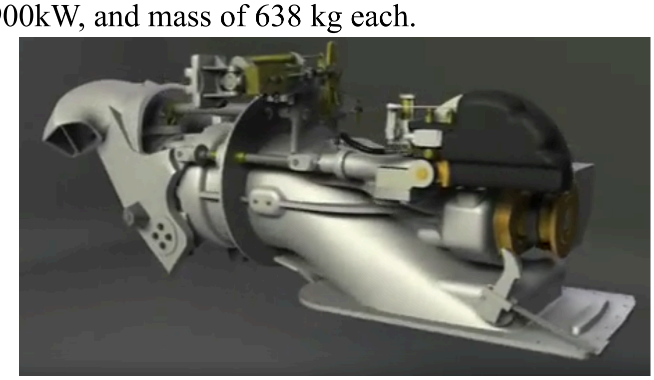


Figure 25: HamiltonJet HJ403 Water-jet drive

9.3 Electric Generator

To meet the electric generation requirements, 2x Onan MDKAF Diesel Gen-sets are selected with a power rating of 27.5 kW, and mass of 533 kg each.

Figure 26: Onan MDKAF Genset

9. Equipment Selection

This section details the selection of commercial equipment that will be integrated into the Dalmatian. Such as life saving equipment, rescue boat, and fire monitors that spray water.

9.1 Lifesaving Equipment

To assist in meeting the fast response requirement and increase the rescue capabilities of the vessel, a rescue boat (RIB) shall be included on board and hung from a Davit arm.

9.1.1 RIBO 340

A five person rescue boat, Survitec Zodiac RIBO 340, was selected due to its small size in order to fit on board the vessel [9]. The RIB is shown with its specification in Figure 26 below.

TECHNICAL DATA

RIBO 340*	CAPACITY	5 persons
	DIMENSIONS L x w	3.40 m x 1.71m
	WEIGHT	641.5kg (operational)
	TOWING	Bow towing points & V bridle / Aft towing V bridle / Transom towing points
	HOISTING	Bow / aft lifting points + sling Release hook SWL ≥ 750kg
	ENGINES	YAMAHA 25HP

Figure 27: RIBO 340

9.1.2 Davit Arm

A Davit arm specified for rescue boats was selected and sourced from Global Davit GmbH. It can withstand loads of over 15kN for the smallest model [10]. More than enough to hold the RIBO 340.

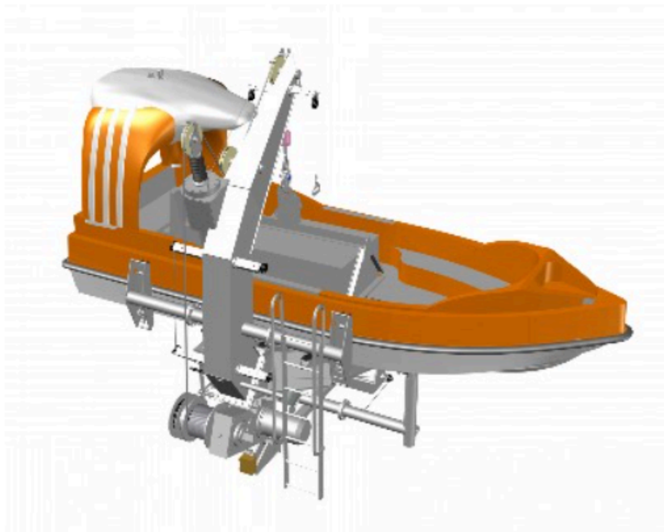


Figure 28: Global Davit GmbH Davit arm

9.2 Firefighting Equipment

In order to put out fires at range, monitors must be mounted on board the vessel. To meet the requirements of a Class A fireboat, the monitor(s) must have a FI-Fi capacity of over 18927L/min [1]. Instead of using dedicated pumps, the water jet propulsor pumps are used, diverting water to the firefighting monitors to reduce complexity and save weight and costs. The Streamaster 2 from Akron Brass meets flow requirements and is selected as the monitor used on board the Dalmatian. It is able to reach a flow of over 28769 L/min and weighs 28.2kg [11].

Figure 29: Streamaster 2 monitor

10. General Arrangements

The arrangement of equipment and compartments is similar to that of Robert Allen's J-2000. The propulsors are located at the aft in order to contact the water and move the ship forward. The engines are directly forward of the propulsors to reduce drive shaft length and complexity. At the center lower midship of the vessel are the gensets and bilge pumps, and they are straddled by fuel tanks and additional storage on either side. At the lower front of the ship is the crew quarters which includes PPE equipment, provision, and other furnishing. Below the lower deck is the ballast to control stability. Above the main deck are the aluminum superstructures, one structure for the wheelhouse and the other for equipment and other supplies. At the aft of the ship above the main deck would be the davit arm with the rescue boat overhanging vessel for quick deployment.

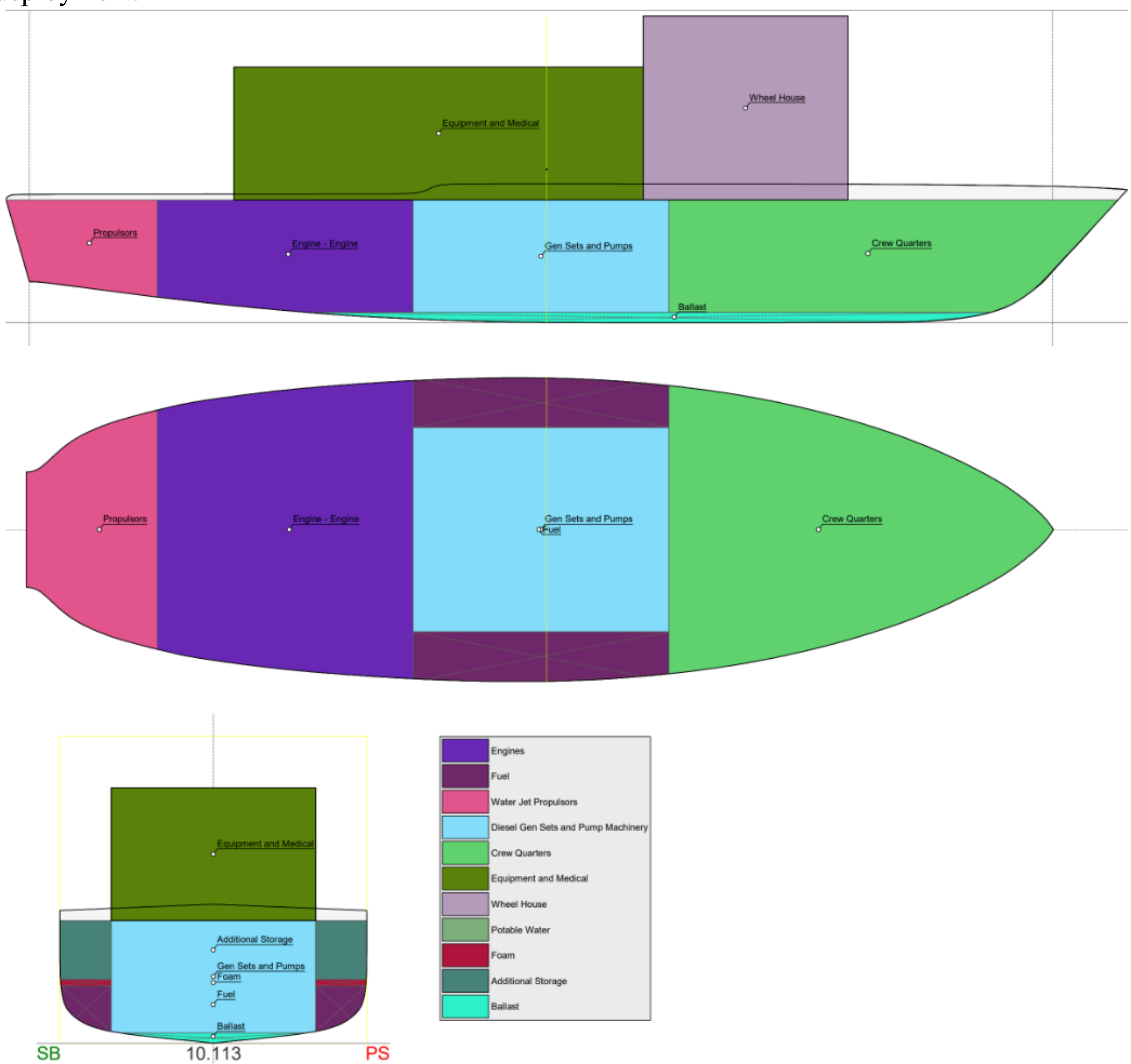


Figure 30: General arrangement of components on vessel

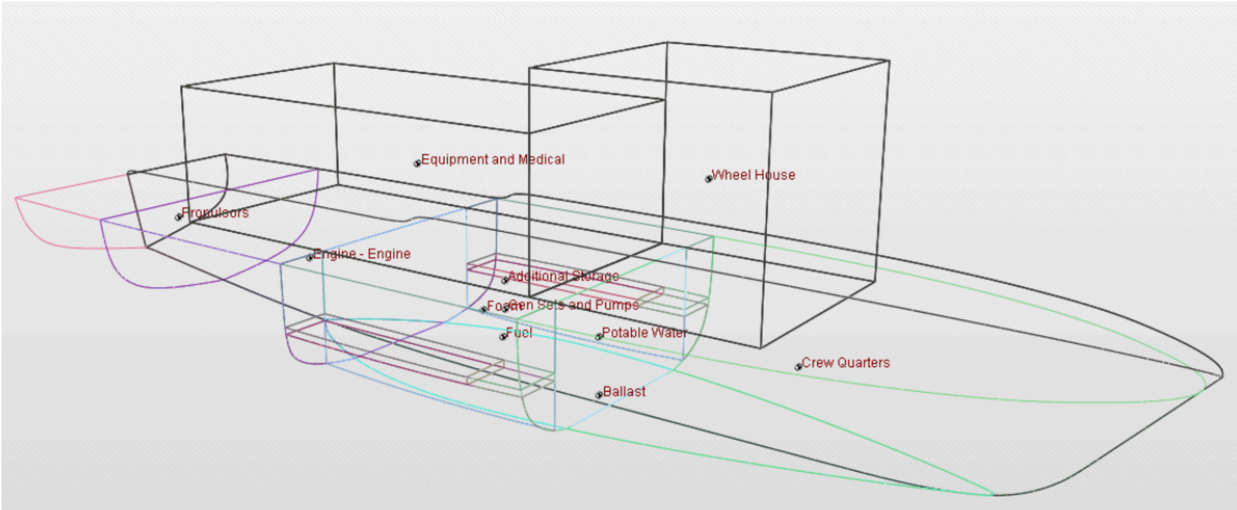


Figure 31: Alternate view of general arrangement

References

[1] J. Ockerhausen, H. Stambaugh, and S. Kelly, ‘Fireboats: Then and Now’, FEMA, Technical Report 146, May 2003. [Online]. Available: https://www.fireboat.org/FEMAfireboatsthennowMay2003.pdf

[2] “Fireboats”, ral.ca. [Online]. Available: https://ral.ca/designs/fireboats/d

[3] William Lyon Mackenzie, freeshipplans.com. [Online] Available: https://freeshipplans.com/free-model-ship-plans/other-ship-plans/william-lyon-mackenzie/

[4] J. G. Stockner and T. G. Northcote, ‘Recent Limnological Studies of Okanagan Basin Lakes and their Contribution to Comprehensive Water Resource Planning’, *J. Fish. Res. Bd. Can.*, vol. 31, no. 5, pp. 955–976, May 1974, doi: 10.1139/f74-111.

[5] ‘Canadian Climate Normals 1981-2010 Station Data - Climate - Environment and Climate Change Canada’. Accessed: Mar. 05, 2024. [Online]. Available: https://climate.weather.gc.ca/climate_normals/results_1981_2010_e.html?searchType=stnProv&lstProvince=BC&txtCentralLatMin=0&txtCentralLatSec=0&txtCentralLongMin=0&txtCentralLongSec=0&stnID=1001&dispBack=0

[6] ‘RAnger 2000 Class fireboat Independence for Philadelphia from Robert Allan Ltd.’, Robert Allan Ltd. Accessed: Mar. 05, 2024. [Online]. Available:https://ral.ca/2007/12/20/ranger-2000-class-fireboat-independence-philadelphia-robert-allan-ltd/

[7] A. Onorati, A. K. Agarwall, R. Payri, M. Gavaises, ‘The future of ship engines: Renewable fuels and enabling technologies for decarbonization’, International Journal of Enginer Research, August 2023. [Online] Available:https://www.researchgate.net/publication/373379477_The_future_of_ship_engines_Renewable_fuels_and_enabling_technologies_for_decarbonization

[8] T. Lamb, Ed., "Chapter 12: Parametric Design," in *Ship Design and Construction*, 3rd ed., Society of Naval Architects & Engineers, 2004.

[9] Survitec Zodiac, "RIBO – Rigid Inflatable Boat," [Brochure], Survitec Group, 2024. [Online]. Available: https://www.surviteczodiac.com/LRDocs/TDS_brochures/RIBO.pdf.

[10] Global Davit GmbH, "Slewing Cranes," 2024. [Online]. Available: https://www.global-davit.de/products/rescue-boat-handling/slewing-cranes/.

[11] "Akron Brass," StreamMaster II with AVM 2000 GPM, Akron Brass, 2024. [Online]. Available:https://www.akronbrass.com/monitors/stream-master-ii-with-avm#product_tabs_specifications.

[12] Delftship User Manual, Delftship Maritime Software, 2023

Appendix: Delftship Outputs

This appendix contains all the reports generated by DELFTShip.
The contained reports are:

1. Design Hydrostatics report
2. Line planes
3. Hydrostatics Report
4. Cross Curves
5. Bonjean Curves
6. Tank Arrangements
7. Tank Capacities
8. Intact Stability Calculation
9. Floodable Length Calculation
10. Calculation of Wind Moments
11. Resistance Calculations