Hull Dimensions Proportions

ANCHOR HANDLING TUG SUPPLY VESSEL

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1.0 Introduction

Preliminary hull dimension proportions for the Anchor Handling Tug Supply (AHTS) design vessel are to be determined for the early stages of the vessel's design. Research and data collection of similar vessels was organized to create a state-of-the-art analysis. Each relationship between one element versus another is analyzed by plotting graphs that display their mathematical expression and regression. Mission criteria parameters are to be considered as a basis when estimating hull dimension proportions; ensuring all parameters and constraints are considered simultaneously. For insight, empirical formulas will be used to estimate hull dimensions for different ship types, which will then be compared to the state-of-the-art estimated hull dimensions. This report will discuss the methodology used in estimating the vessel design particulars (i.e. displacement, main dimensions, and hull form).

An executive summary of the design vessel's estimated proportions can be found below:

- Displacement (Δ) = 10170 tonnes
- Length = 92.0 m
- Beam = 22.3 m
- Draft = 7.8 m
- Depth = 9.7 m
- Freeboard = 1.9 m
- Block Coefficient (C_B) = 0.62
- Froude Number (F_n) = 0.29
- Deadweight Coefficient (C_D) = 0.43
- Deadweight (DWT) = 4500 tonnes

2.0 Mission Criteria Parameters

Mission criteria parameters and design constraints accounted for in the estimation of the design vessel's initial displacement, main dimensions, and hull form are listed below:

- Deadweight = 4500 tonnes
- Maximum speed = 17 knots
- Bollard pull = 300 tonnes
- Maximum port restrictions = 150 m by 23 m by 8 m (L×B×T)

3.0 Initial Displacement

Initial displacement of the Anchor Handling Tug Supply design vessel was estimated by using the deadweight ratio. The formula for deadweight coefficient was used to find the initial displacement using the following:

- Deadweight coefficient (C_D = 0.43)
- Deadweight (DWT = 4500 tonnes)

The deadweight coefficient of 0.43 was estimated by finding the midrange of all deadweight coefficients offered by six total vessels organized in the state-of-the-art excel spreadsheet. Estimation of C_D workings can be found below:

$$Midrange = \frac{HIGH + LOW}{2}$$

$$= \frac{0.48 + 0.38}{2}$$

$$\therefore C_D = 0.43$$

The set deadweight and deadweight coefficient were plugged into the deadweight coefficient formula to find the initial displacement (Δ_1):

$$C_D = \frac{DWT}{\Delta_1}$$

$$\Delta_1 = \frac{DWT}{C_D}$$

$$= \frac{4500}{0.43}$$

$$\therefore \Delta_1 = 10465\ tonnes$$

4.0 Length

Practical length for the Anchor Handling Tug Supply (AHTS) design vessel was estimated by plugging in the following known parameters into the equations: displacement (10170 t), vessel speed (17 kts.), deadweight (4500 t), and Froude number (0.29). Empirical and state-of-the-art equations that were used to estimate the different lengths can be found in the x-axis in Figure 1 below:

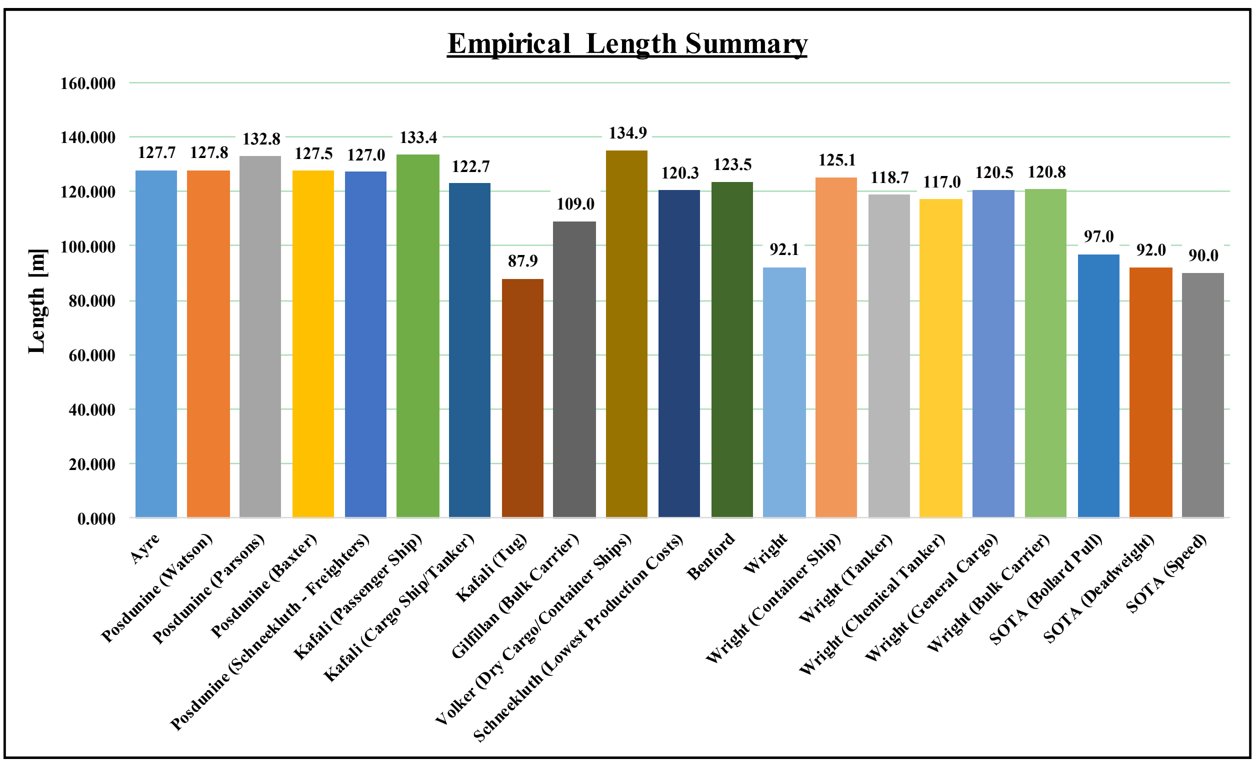

Figure 1: Empirical Length Summary.

Bollard pull, deadweight, and vessel speed were used in the state-of-the-art analysis to determine which had a stronger relation to the length-over-all (LOA). Length-over-all compared to the deadweight was the most preferable as deadweight is one of the design constraints. The deadweight of 4500 tonnes was applied to the graph below, leading to a length-over-all value of 92.0 m as shown in Figure 2 below:

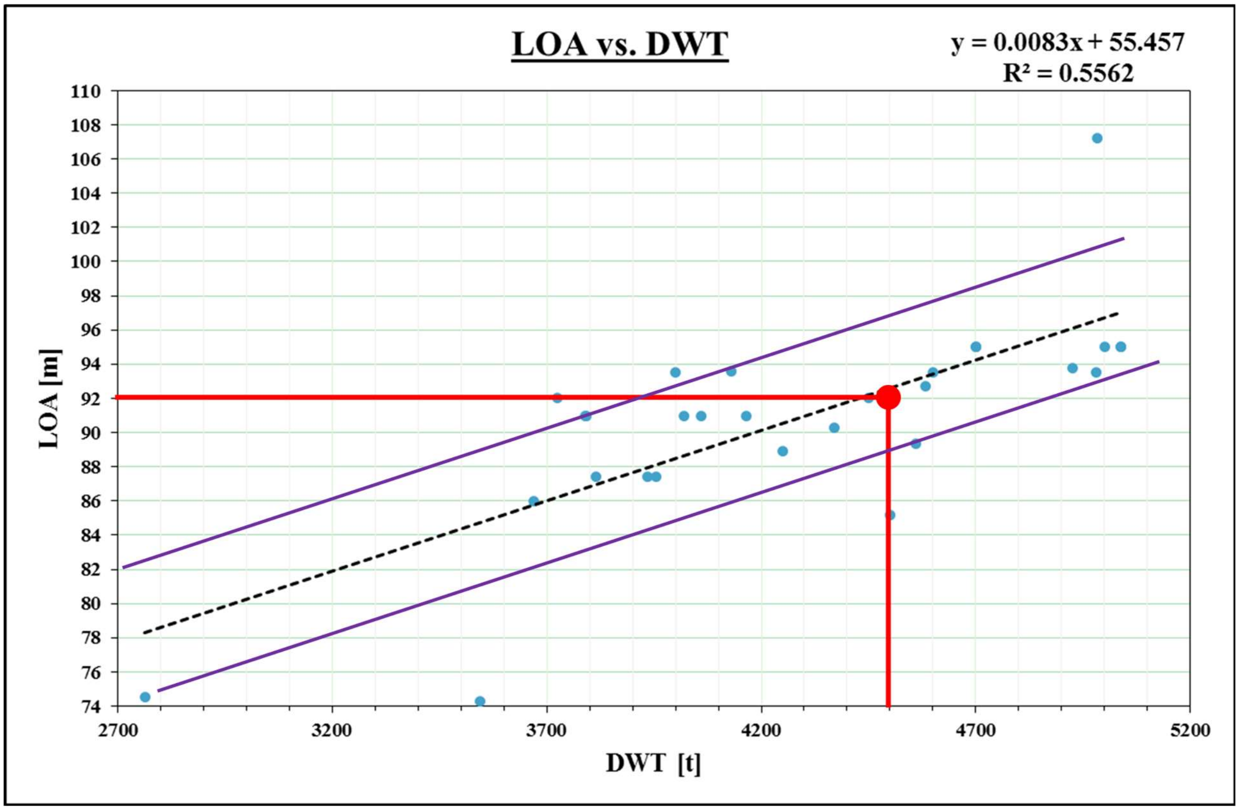

Figure 2: Length-over-all versus Deadweight.

Finally, a decision must be made on the design vessel's length, which was determined to be 92.0 meters long. The chosen length signifies an appropriate magnitude for its given vessel speed when analyzing the graph above. We should keep in mind that increased length at a constant displacement may cause a decrease in the capacity where sufficient capacity in AHTS vessels is highly valued for its' duties. Also, the increased length will influence the vessel's turning ability and freeboard to worsen and increase, respectively. It is to be noted that AHTS vessels with inverted bow typically have the same magnitude in both, length-over-all and load-waterline-length.

5.0 Beam

Beam for the Anchor Handling Tug Supply design vessel was estimated by analyzing similar ships' bollard pull, length, and deadweight compared to their corresponding beam. Also, empirical formulas were used as shown in Figure 3 below:

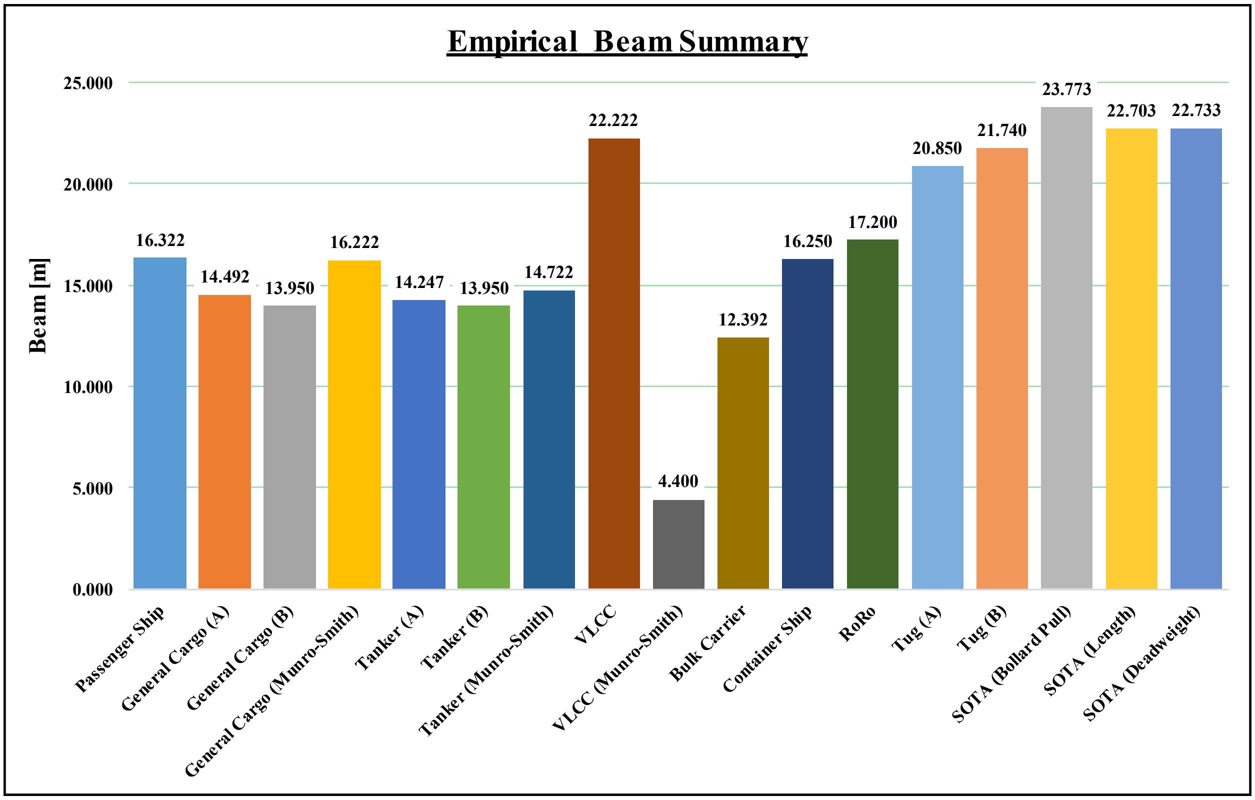

Figure 3: Empirical Beam Summary.

Bollard pull, deadweight, and chosen length were used in the state-of-the-art analysis to determine which had a stronger relation to the beam. Each plotted graph developed from the state-of-the-art analysis displayed a collection of data points acting as a series on a line representing a 22 m beam. The beam of 24 m has a similar scenario but in fewer numbers of data points. Both beam magnitudes appear to remain constant as any of the three following vessel parameters increases.

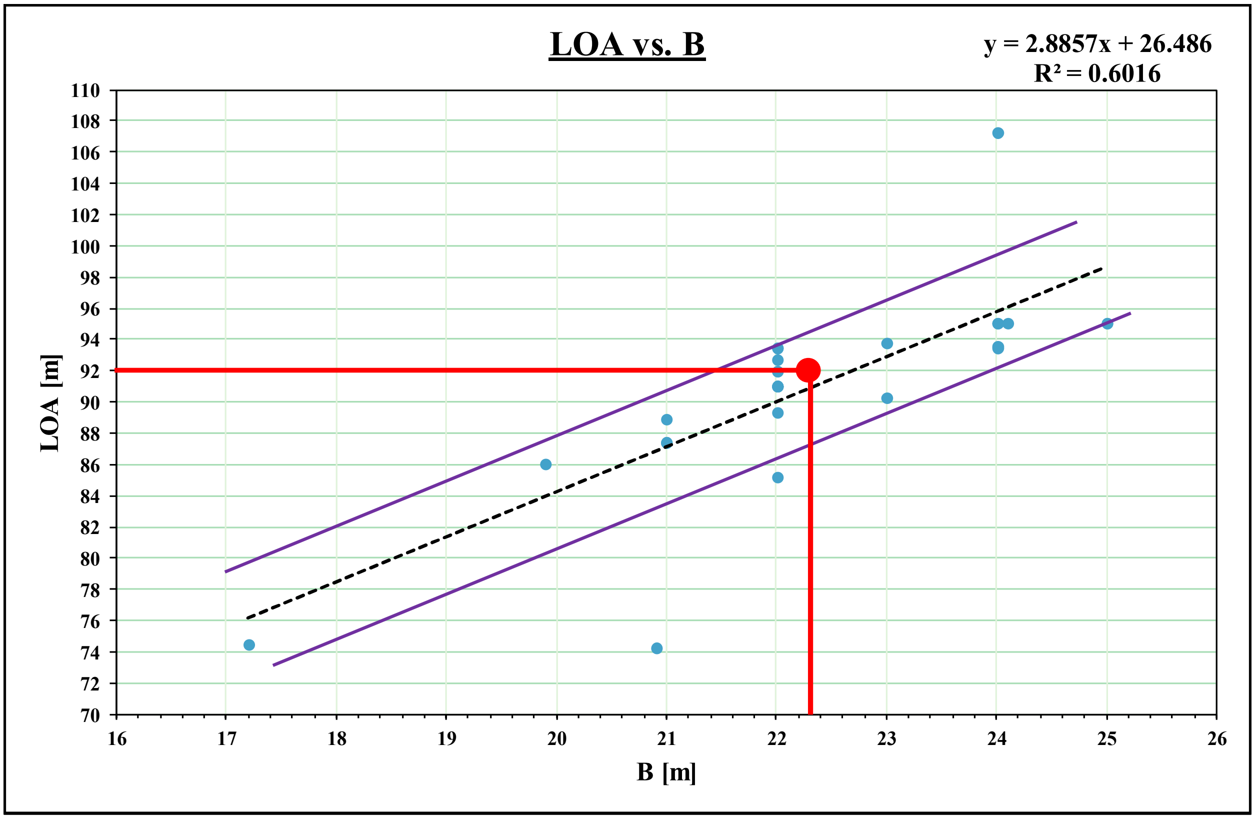

Figure 4: Beam versus Length-over-all.

Finally, a decision must be made on the design vessel's beam where the Beam versus Length-over-all graph above will be used; After analyzing, the beam of the design vessel was decided to be 22.3 meters wide, being within the design lanes. The length-over-all was a fitting source to compute beam since the length to beam ratio affects the vessel's powering and directional stability. The beam widths for "SOTA (Bollard Pull)" and "SOTA (Deadweight)" have larger magnitudes offering improved initial stability characteristics. However, the state-of-the-art analysis shows the strongest regression for the beam of 22 m. The likely reason why the 22 m beam is most popular is that of savings in weight and cost of the design vessel's hull.

6.0 Block Coefficient

The block coefficient is to be determined as it indicates the required fullness of the Anchor Handling Tug Supply design vessel's underwater hull form. State-of-the-art vessels' block coefficients were computed and compared to the empirical formulas' computations. The following state-of-the-art and empirical equations that were used to estimate block coefficient can be found in the x-axis in Figure 5 below:

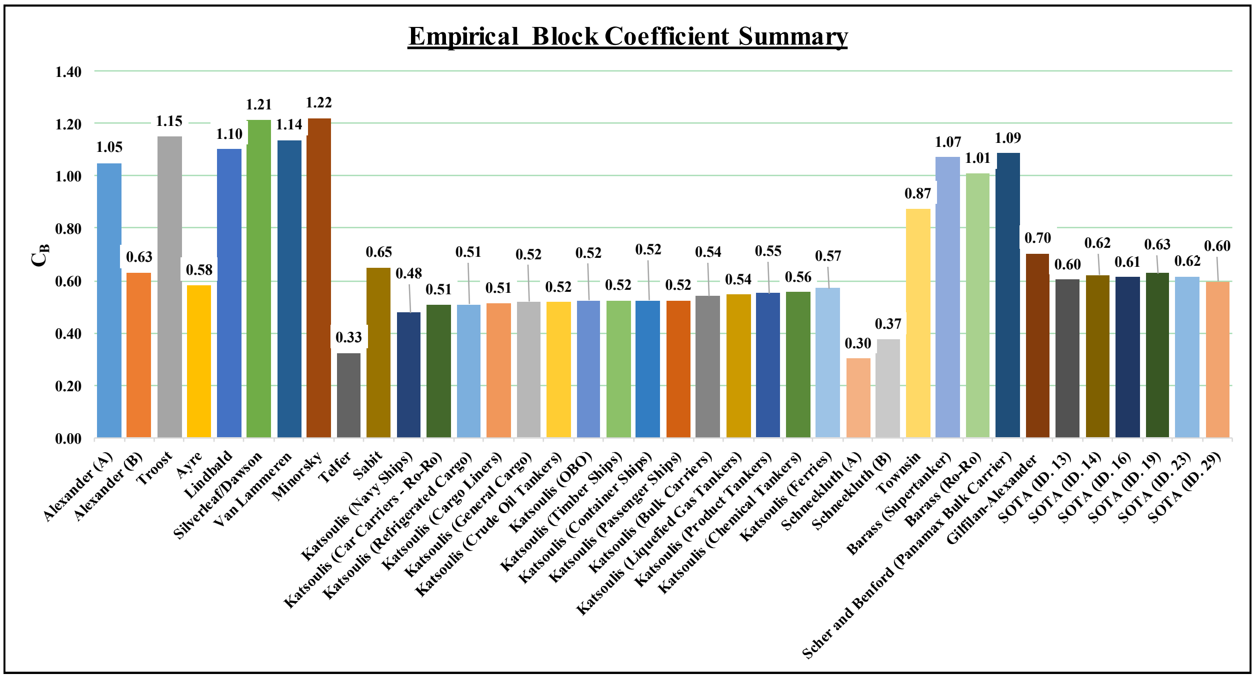

Figure 5: Empirical Block Coefficient Summary.

Finally, the block coefficient of the design vessel was determined by looking at the similar ships' block coefficient; where, a block coefficient value of 0.62. Fuller underwater hull form due to the result of a high block coefficient will offer better maneuverability and more capacity overall for the AHTS design vessel.

7.0 Draft

The draft of the design vessel does not have any significant influence on the overall vessel so the draft will be determined using the Length-over-all versus Draft graph below. Using the length-over-all of 92.0 m has led a draft value of 7.8 m. The draft value of 7.8 m is a trend, which can be seen in Figure 6 below:

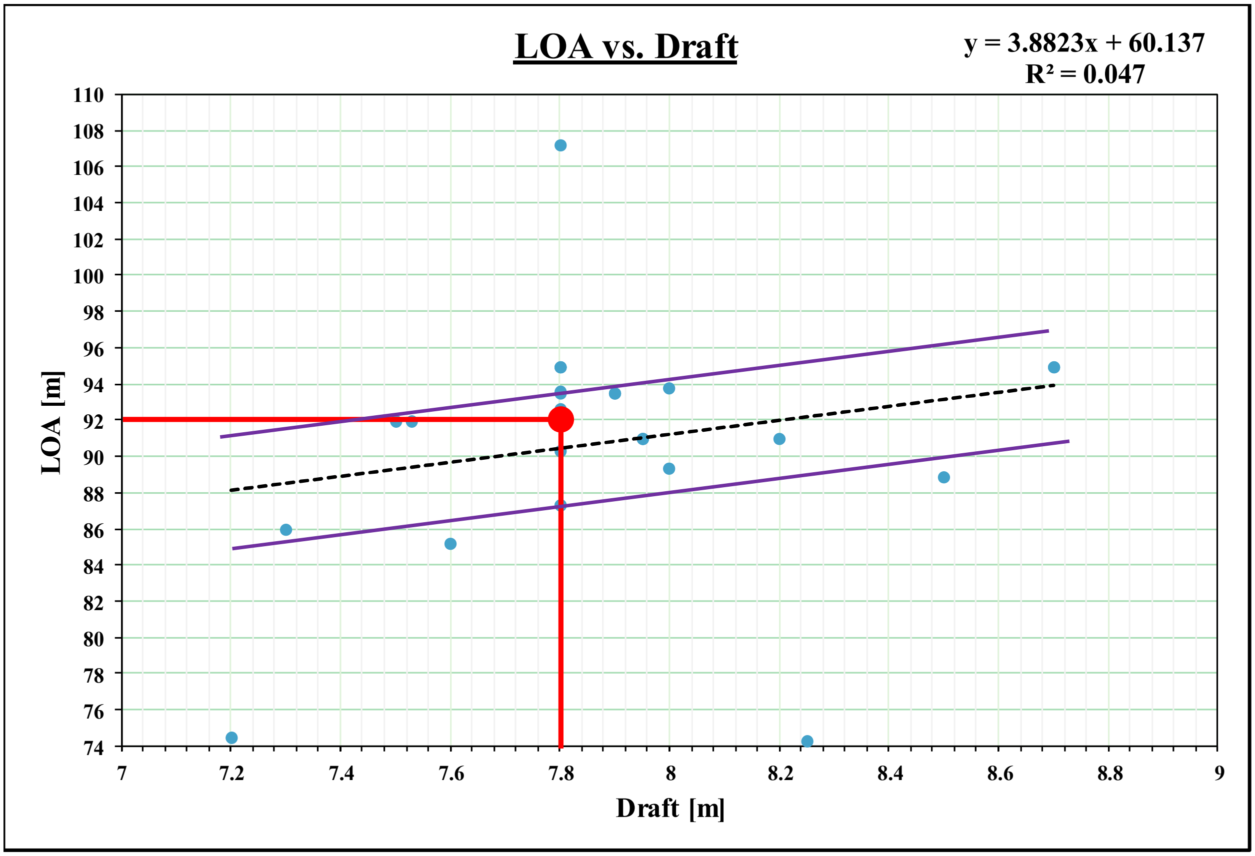

Figure 6: Length-over-all versus Draft.

8.0 Depth

Depth was determined by analyzing the state-of-the-art spreadsheet, taking consideration in the draft, beam, and length-over-all. Each consideration was computed and compared to the empirical formulas' computations. The following state-of-the-art and empirical equations used to estimate block coefficient can be found in the x-axis in Figure 7 below:

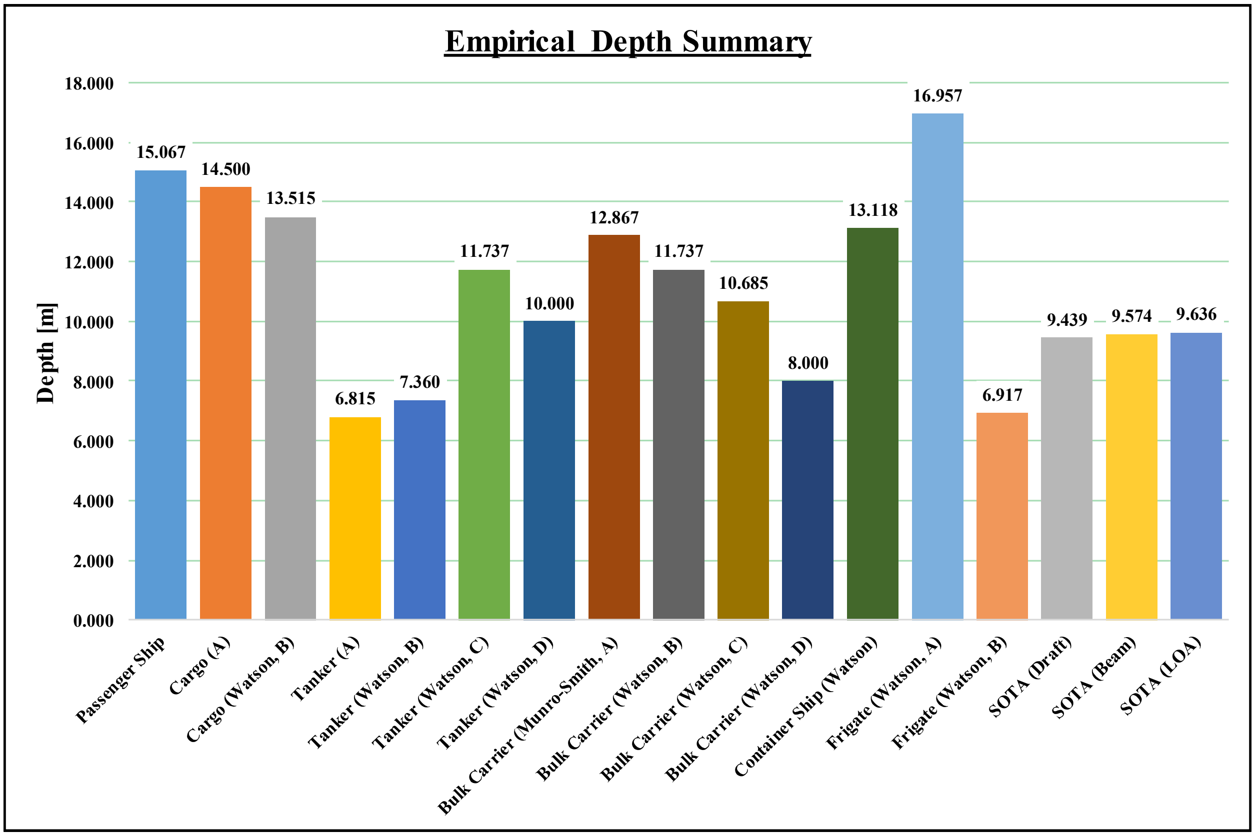

Figure 7: Empirical Depth Summary.

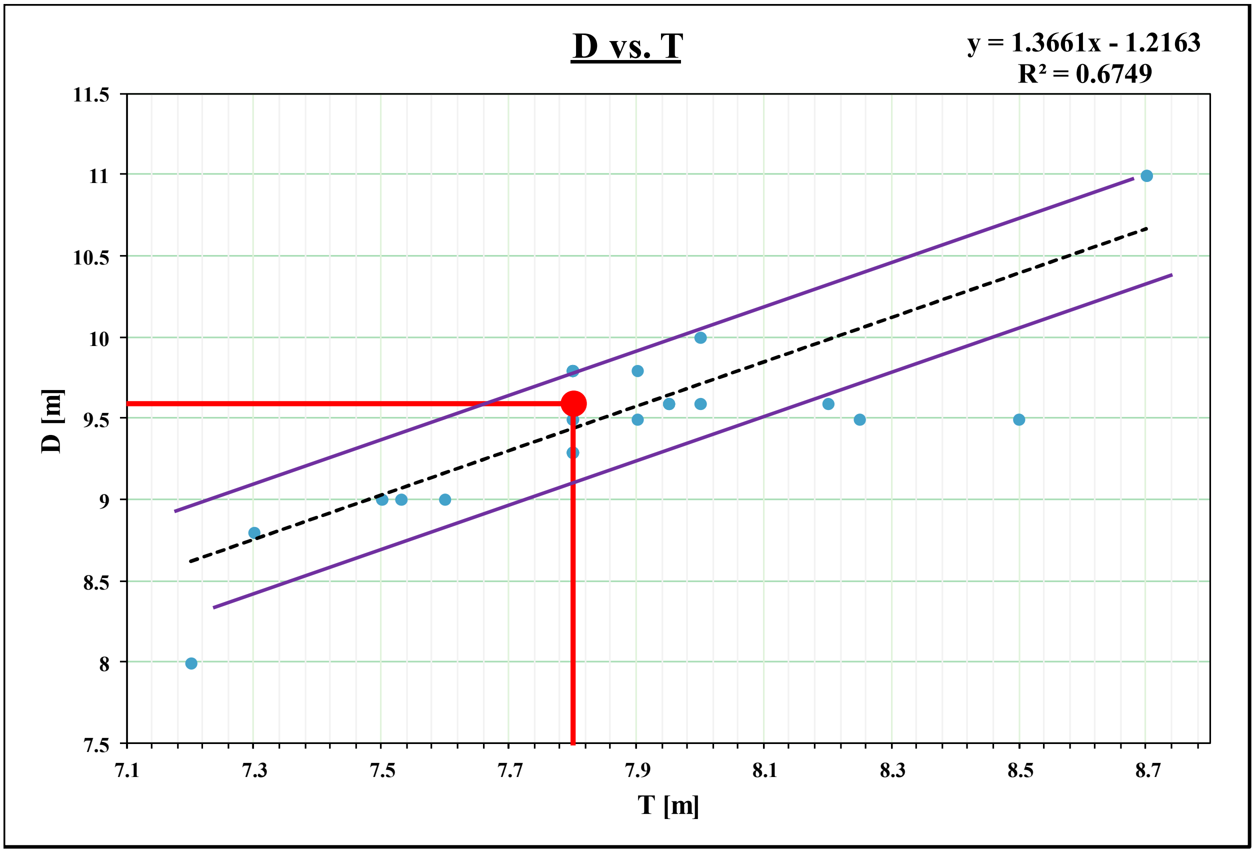

Figure 8: Depth versus Draft

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The freeboard of the design vessel was heavily considered as it affects the bulkheads arrangement (i.e. floodable lengths curve), where a greater depth and lower draft will increase the overall freeboard; the freeboard being greater will help improve the floodable lengths curve. Using the draft determined above, 7.8 meters, the value was plugged into the graph in Figure 8 above. Finally, a value of 9.7 meters was decided to be the ship's depth.

9.0 Freeboard

Freeboard of the Anchor Handling Tug Supply design vessel was computed using the determined depth and draft from above as shown below:

$$Freeboard = Depth - Draft$$
$$= 9.7\ m - 7.8\ m$$
$$\therefore Freeboard = 1.9\ m$$

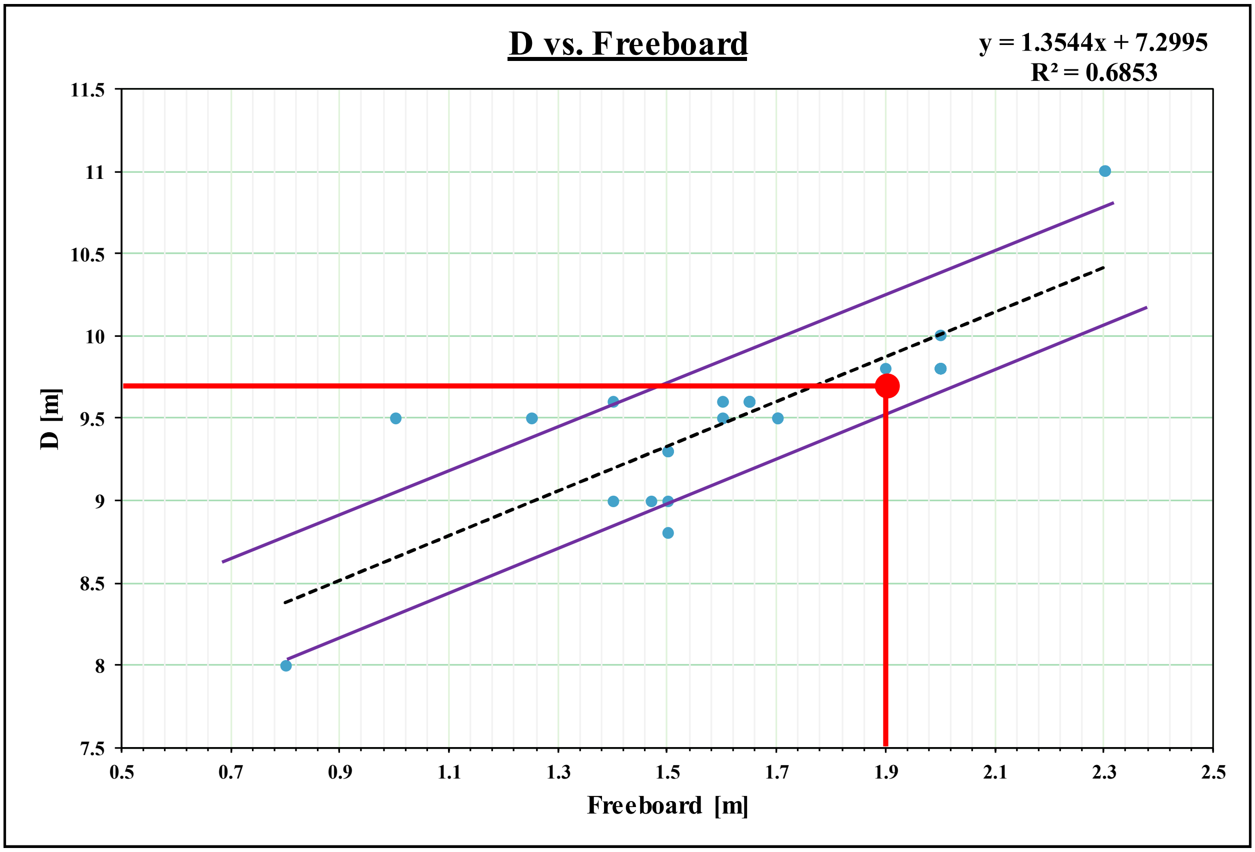

Figure 9: Depth versus Freeboard.

The estimated freeboard for the Anchor Handling Tug Supply design vessel with its corresponding estimated depth can be seen in Figure 9 above. Vessels with similar depth can be seen of also having similar freeboard from using the state-of-the-art ship data. The freeboard estimated height for the AHTS design vessel is to be 1.9 meters.

10.0 Displacement Check

Displacement check is required to determine the percentage of difference from the initial displacement and the new displacement (i.e. within ± 5%). First, the displacement equation will be used to determine the new displacement then a percentage of difference is calculated. Refer to the following displacement check computations below:

$$\Delta_2 = L \times B \times T \times C_B \times \rho$$
$$= 92.0 \times 22.3 \times 7.8 \times 0.62 \times 1.025$$
$$\therefore \Delta_2 = 10170 \; tonnes$$

$$Difference\ (\%) = 100\% - \left[\left(\frac{\Delta_2}{\Delta_1}\right) * 100\%\right]$$
$$= 100\% - \left[\left(\frac{10170}{10465}\right) * 100\%\right]$$
$$\therefore Difference\ (\%) = -2.91\%$$

The new displacement (Δ_2) was plugged into the deadweight coefficient equation to verify if deadweight coefficient (C_D) remained the same under the set deadweight (4500 t) as shown below:

$$C_D = \frac{DWT}{\Delta_2}$$
$$= \frac{4500}{10170}$$
$$= 0.44$$

Initial displacement and the new displacement only have a slight difference in value (-2.91%), which only increased the overall deadweight coefficient by approximately 2% (0.43 to 0.44). The final estimated displacement of the design vessel is to be 10170 tonnes.

11.0 Conclusion

Anchor Handling Tug Supply design vessel preliminary hull dimension proportions determined using the methodology in each topic should prove to be an economical and efficient set of parameters. State-of-the-art analysis and empirical formulas have narrowed down a clear definition of what proportions suit the AHTS design vessel to be able to perform its duties efficiently. Each mission criteria parameter and constraint were considered simultaneously when analyzing the different mathematical relationships and computations. The final summary of the design vessel's estimated proportions is to be considered to be incomplete as other design factors are to be investigated and considered. Several new designs will be made, which will require a series of modifications to the hull dimensions proportions of the design vessel.

Final summary of the design vessel's estimated proportions can be found below:

- Displacement (Δ) = 10170 tonnes (vs. 10465 tonnes ≈ -2.91% difference)
- Length = 92.0 m
- Beam = 22.3 m
- Draft = 7.8 m
- Depth = 9.7 m
- Freeboard = 1.9 m
- Block Coefficient (C_B) = 0.62
- Froude Number (F_n) = 0.29
- Deadweight Coefficient (C_D) = 0.43
- Deadweight (DWT) = 4500 tonnes

12.0 References

Lamb, T. (n.d.). *Ship Design and Construction, Volumes 1-2.* Society of Naval Architects and Marine Engineers (SNAME).

APPENDIX

Appendix A – State-of-the-Art Analysis

(See Electronic Copy of Excel Spreadsheet)

Appendix B – Proportions

(See Electronic Copy of Excel Spreadsheet)