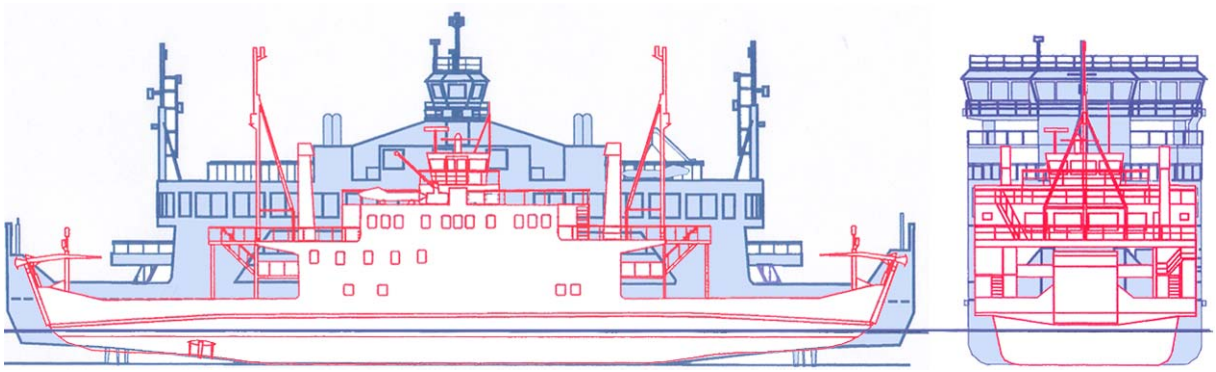
An Analysis of Lymington-Yarmouth Ferry Dimensions

The Lymington River Association



Version 2.0 - 8/5/08

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Introduction

Central to our concerns about Wightlink's proposed introduction of the Wight-Class ferries onto the Lymington River is their size. The Navigational Review commissioned by Wightlink stated, *"It is clear ……that the existing channels are "at the limit" for the existing C Class at low water."* It is therefore very important to understand the actual differences between the existing C-Class ferries and the *"not much bigger"* W-Class ferries.

This analysis is based on Wightlink published information. Measurements are taken from the plans using CAD software.

The report starts with a summary of the measurements. After that it gives more detail of how these measurements were derived. While every effort has been made to maximise the accuracy of this information, it is still based upon our best efforts and errors may have crept in (as they have with the figures provided by Wightlink).

Throughout this report, W-Class areas have been outlined in blue and C-Class in red.

Document Split

Version 1 of this document discussed both the dimensions of the ferries and their carrying capacity. In Version 2, these topics have been separated into separate documents. This is to keep the documents to a manageable size. It is also because the natures of the analyses are somewhat different.

This Dimensions document concentrates on the externals of the ferries; while there have been some inconsistencies in the information available, we feel that the results are uncontroversial (even if they may be very alarming to some people).

Revisions

Version 2.0 incorporates minor changes and refinements including some new diagrams.

Wightlink Review

Wightlink reviewed Version 1.0 of this document and made some minor comments "The above does not constitute an exhaustive review of the document but does highlight some key aspects of inaccuracy and/or error." The only inaccuracy in the dimensions was to the waterline length and area; these have been updated. (See also the LRA Analysis of Lymington-Yarmouth Ferry Capacity report on the LRA web site.)

1 Analysis Summary and Conclusions

The purpose of this report is to summarise our analysis of the dimensions of the two ferry classes. In general, it does not attempt to evaluate the impact of the differences.

Figure 1. Artist's Impression of the W-Class

(from the Wightlink website)

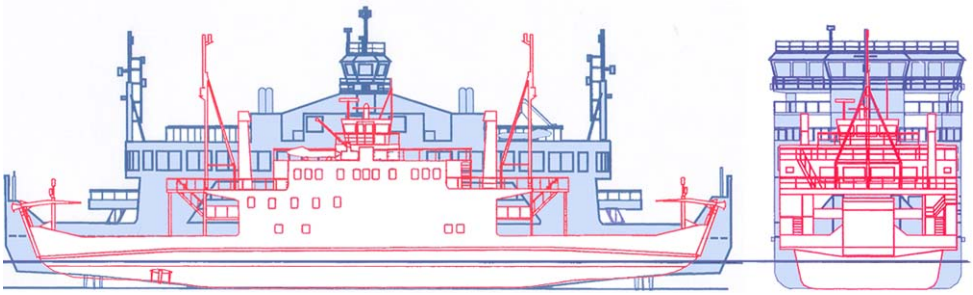

Figure 2. Comparison of the profiles and cross-sections of the W-Class and C-Class

(from information on Wightlink website and photographs)

Note that in this document, two draughts are used: the maximum design draught and the lesser Wightlink expected operational draught.

1.1 Overhead View

(For details see Section 3)

Wightlink have emphasised that the "footprint" of the W-Class is about the same that of the C-Class. The view from above W-Class is 19% larger than that of the C-Class. Based on Wightlink figures the "waterprint" is 38% larger and the displacement of water is 76% greater.

Comparison of Overall Dimensions and Displacement

		C-Class	W-Class	Difference
Overall	Lengths	58.0 m	62.4 m	+ 7.6%
	Max Beams	15.2 m	16.1 m	+ 6.0%
	Max Plan Areas	760 m^2	905 m^2	+ 19%
Draught	Maximum	2.28 m	2.3 m	+0.9%
	Expected Operational	2.28 m	2.13 m	-6%
Waterline	Lengths	55.55 m	60.92 m	+ 9.7%
	Max Beams	12.2 m	16 m	+ 30%
	Areas	591 m^2	816 m^2	+ 38%

1.2 Displacement, Deadweight and Operational Draught

(For details see Section ??)

The displacement and deadweight of the W-Class are both significantly greater than that of the C-Class

		C-Class	W-Class	Difference
	Displacement	850 tonnes	1495 tonnes	+76%
	Operational Deadweight (1)	156 tonnes	215 tonnes	+ 38%
	Maximum Deadweight	156 tonnes	330 tonnes	+ 111%
	Operational Draught	2.28 m	2.13 m	-7%
	Maximum Draught	2.28 m	2.3 m	+ 1%

(1) The working deadweight was calculated based upon the Wightlink stated working draught of 2.13 metres.

1.3 Profile from Abeam

(For details see Section 4.1 and 5.1)

Wightlink's Navigational Review stated that the above-water profile of the W-Class is 84% greater than that of the C-Class. The BMT SeaTech Phase 1 Report gives 82.2% to 105.3%. Based on the latest information available to us, we measured the profile at the operational draught to be 95% greater (see Section 4.1).

One of the important implications of this increase is the increase in windage. Wightlink have told us that they have not performed any wind tunnel tests and we are not in a position to do so either. However we have done some windshear calculations (see Section 4.3); these show that, allowing for wind shear, the beam windage of the W-Class at operational draft would be at least 138% greater than that of the C-Class.

This increase in sideways force is not compensated by an equivalent increase in the underwater profile. (Note that the underwater shape and area has a reducing effect as the ferry slows and gives no lift when a ferry is stationary waiting to cross in the river or in an emergency.)

Summary of Beam Profile and Windage

		C-Class	W-Class	Difference
Profiles above-water from abeam				
	Operational Draught	304 m^2	606 m^2	+ 99%
	Maximum Draught	304 m^2	595 m^2	+ 95%
Windage taking into account wind shear				
	Ratio of force at working draught	1	2.38	+ 138%
Profiles below-water from abeam				
	Operational Draught	104 m^2	101 m^2	-3%
	Maximum Draught	104 m^2	112 m^2	+ 8%
	Above/below ratio	3.08	6	+ 94%

1.4 End-on Profile

(For details see Section 4.2)

The above-water end-on profile of the W-Class from ahead is 68% greater than that of the C-Class.

1.5 Power

(For details see Section 0)

This report does not discuss the engine power of the ferries. However, for completeness, the figures from the Wightlink Navigational Review are included.

Summary of Engine Power

	C-Class	W-Class	Difference
Number of Engines (1)	2	4	
Total power available	800 hp (2)	2360 hp	+ 195%
Thrust/displacement ratio	1	1.67	+ 67%

(1) Wightlink say that for "normal" running only 3 will be used at one time.
(2) This figure is an estimate (see Navigational Review) ; we believe that one of the C-Class has different engines from the other two..

This report discusses the propulsion units in Section 5.3).

The rest of this report contains more detail and the background as to how the figures were obtained.

2 The Plans

2.1 The Wightlink Class (ex R-Class)

The main source used for the overall dimensions of the W-Class has been the profile and cross-section of the ferry on the Wightlink web site (see below). It is our view that these, while not the most detailed, are probably the most accurate overall.

Figure 3 Profile of W-Class and Cross-section of W-Class

The following have also been used:

- The Hart Fenton plans included in the Gifford Environmental Appraisal (see below) used for overhead views and some detail measurements.

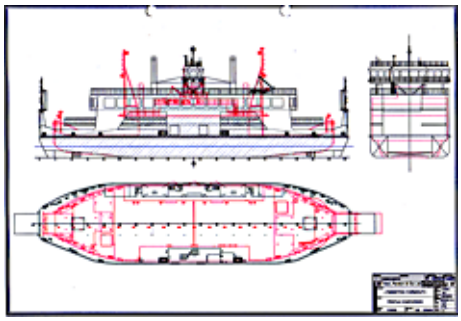

Figure 4 Hart Fenton Plan

- Artists' impressions of the W-Class from the Wightlink web site (see Figure 1),
- Photographs of the W-Class under construction from the Wightlink web site (see Picture 4 to Picture 8).

The major variations of the Hart Fenton plans from those on the Wightlink website are:

- A bigger deck house and other changes to superstructure including a raised bridge.
- The removal of the skeg at either end.
- Shorter protruding mezzanine.

2.2 The C-Class

For C-Class measurements, the original plans from Robb Caledon Shipbuilders have been used.

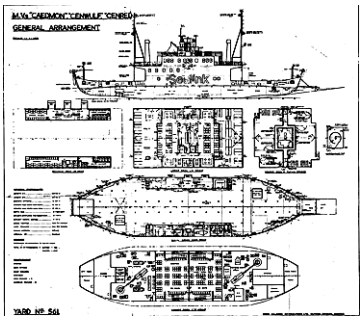

Figure 5 Robb Caledon Plan

The following have also been used

- Recent photographs of the C-Class

Picture 1. Profile of C-Class

- The Hart-Fenton plans, which include the C-Class;

The major variations from the Hart Fenton plans are:

- The structure to provide access to the mezzanine (which is not shown on the RC plans either as it was a later addition),
- The different end profile.

3 Overhead View

The "Seagull's Eye View" can be derived directly from the Hart Fenton plans.

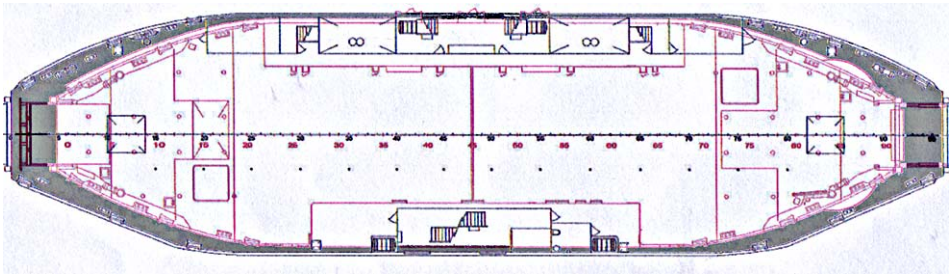

Figure 6 Seagulls' Eye Views

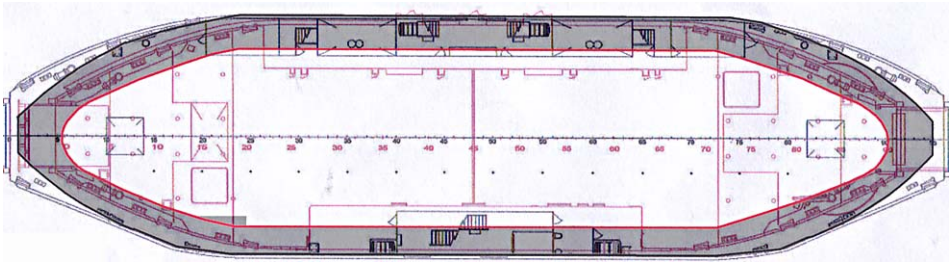

Figure 7 Waterline Footprints

Comparison of Overhead Dimensions

		C-Class	W-Class	Difference
Overall	Lengths	58.0 m	62.4 m	+ 7.6%
	Max Beams (1)	15.2 m	16.1 m	+ 6.0%
	Max Plan Areas	760 m^2	905 m^2	+ 19%
Waterline	Lengths	55.55 m	60.92 m	+ 9.7%
	Max Beams	12.2 m	16 m (2)	+ 30%
	Areas (3)	591 m^2	816 m^2	+ 38%
Flat Bottom	Lengths	26.7 m	26.7 m	+ 0%
	Beams	9.8 m	13.5 m	+ 38%
	Areas	260 m^2	360 m^2	+ 38%

(1). Both the Hart Fenton plans and the plans on the Wightlink website show that the bridge of the W-Class overhangs the rest of the hull; therefore the actual maximum beam is slightly greater than that shown here.

(2). Table 3.1 in Section 3.1.1 of the Navigational Review gives a beam at waterline for the W-Class of 14.4m. From the plans and the photographs, this is clearly a mistake.

(3) Wightlink figures.

4 Above Water Profiles

4.1 The Profile from Abeam

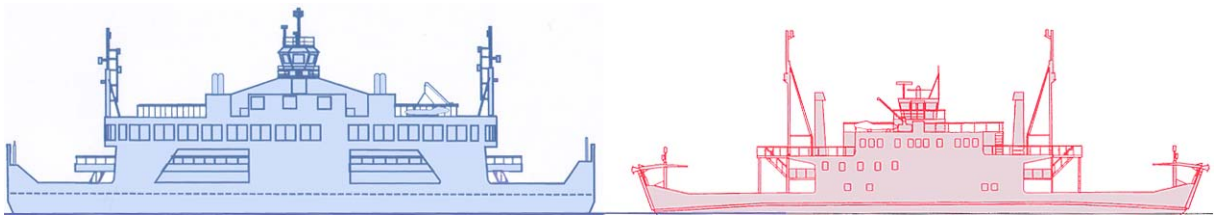

Figure 8 Beam Profile

There are various ways to calculate the profile. Our analysis excluded all railings and the extending mezzanine (and any cars thereon) on the W-Class. Should the railings on the C-Class be replaced by glass panels on the W-Class, the actual and relative windage of the W-Class will be increased,

Comparison of Above-water Beam Profile Dimensions

		C-Class	W-Class	Difference
Lengths				
	Overall	58.0 m	62.4 m	+ 7.6%
	Waterline	55.55 m	60.92 m	+ 9.7%
Height to top of Bridge		12.8 m	18 m	+ 40%
Profiles from abeam				
	Operational Draught	304 m^2	606 m^2	+ 99%
	Maximum Draught	304 m^2	595 m^2	+ 95%

One inaccurate and misleading profile diagram has been used and is continuing to be used in comparing the ferry profiles:

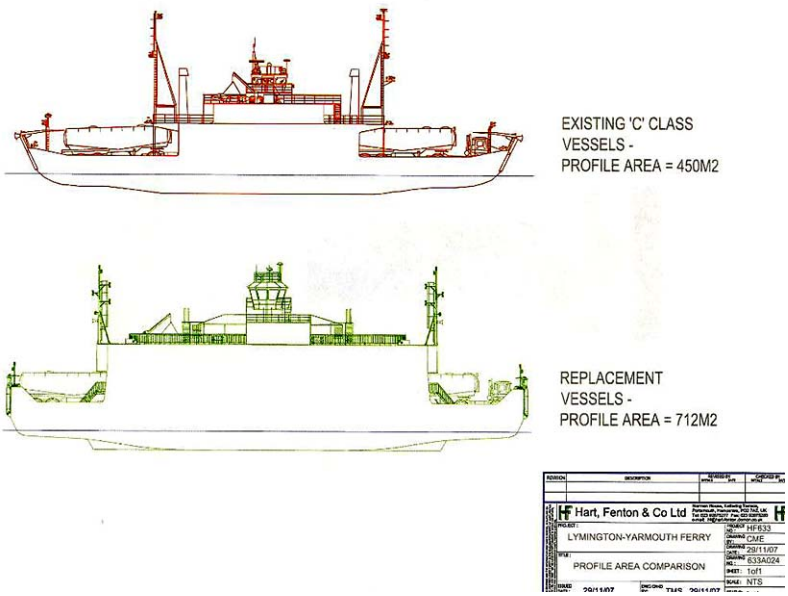

Figure 9 Profile with over-sized Trucks

Apart from showing HGVs which Wightlink claims will not usually use the Lymington-Yarmouth route, it also shows 5 metre high HGVs on both ferries. The C-Class, unlike the W-Class, will only take 4.15 metre HGVs (See the LRA Analysis of Lymington-Yarmouth Ferry Capacity report on the LRA web site.)

4.2 The Profile from Ahead

The Hart-Fenton plans only show a cross section of the ferries. The end-on view in Figure 10 has been deduced from the cross section, the artists' impressions and photographs of the C-Class and of the W-Class under construction.

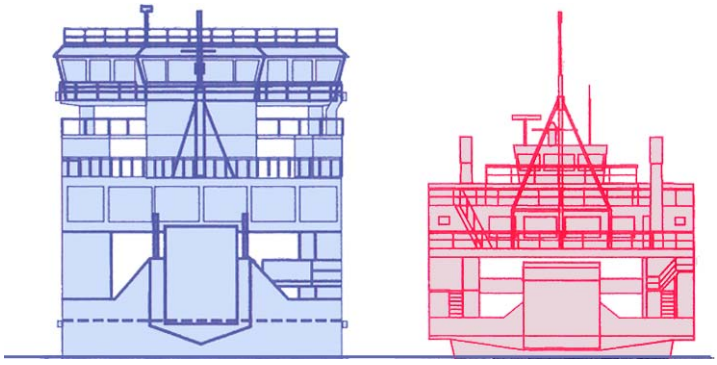

Figure 10. End Profile

Comparison of Above-water End-on Dimensions

		C-Class	W-Class	Difference
Beam				
	Overall	15.2 m	16.1 m	+ 6%
	Waterline	12.2 m	16.1 m	+ 32%
Profiles from ahead				
	Operational Draught	149 m^2	251 m^2	+ 68%
	Maximum Draught	149 m^2	248 m^2	+ 66%

4.3 Effect of Wind - Windshear

The profile area comparison of the two ferries does not give a picture of the effect of the wind on due to the greater height and length of the W-Class superstructure. This is because wind speed increases with height (windshear). To determine the force caused by wind, the increase in wind speed as height is increased the windshear was calculated. The result is that the sideways force on the W-Class beam profile in the equivalent wind would be 138% greater than that of the C-Class.

Comparison of Windage

		C-Class	W-Class	Difference
Profiles at Operational Draught				
	Above Water	304 m^2	606 m^2	+ 98%
Windshear				
	Ratio of forces	1	2.38	+ 138%

Windshear calculation (for those interested)

The following formula was used:

Wind speed = Wind speed at 10m * ((Height in metres/10m) ** Roughness Factor)

The Roughness factor indicates the friction caused by the surface over which the wind has passed. A factor of .1 is used for the open see; in this case .15 was used to allow for the salt marshes and other minor obstructions exposed at the critical state of low water.

The pressure exerted is the square of the wind speed, so the wind speed was cubed at each height:

Increased Pressure = (lateral area * windshear) ** 2

The windshear was calculated for the profile areas to .5, 1, 1.5, 2 and 2.5 metres. Thereafter the windshear increase becomes close to linear so the total area above was applied to the centre of area of profile above 2.75 metres.

(To be pedantic: when looking at the ferries we should say that the wind speed reduces with reducing height. This is because, by convention, the wind speed which is quoted on, say weather forecasts is measured at 10 metres.)

4.4 Effect of Wind - Drift Angle

The Navigational review suggested that the W-Class might have to travel at a drift angle in order to reduce or counteract strong winds from abeam.

For the record, at a drift angle of 5%, the increased "apparent beam" of the W-Class across the river is 19.3 metres and, at 10%, 22 metres.

4.5 Visibility

The visibility from the bridge of the W-Class is a concern which seems to be shared by Wightlink who have, in the final design, raised the bridge by 1.5 metres over the original Hart Fenton Plans. Presumably this is to provide better visibility over the prolonged upper deck. The fitting of CCTV to assist in the navigation of the ferries on the River has been discussed.

The bridge on the W-Class is 5.2 metres higher than that of the C-Class.

The W-Class bridge also extends just outside the point of maximum beam on the rest of the hull. This allows crew to be stationed to watch down the side of the hull and to see round the loading ramp. The same can be achieved on the C-Class, however the crewmember must be outside on the deck and lean over the rail.

The following shows the visibility of the water surface (without CCTV) from the centre and beam of the bridge:

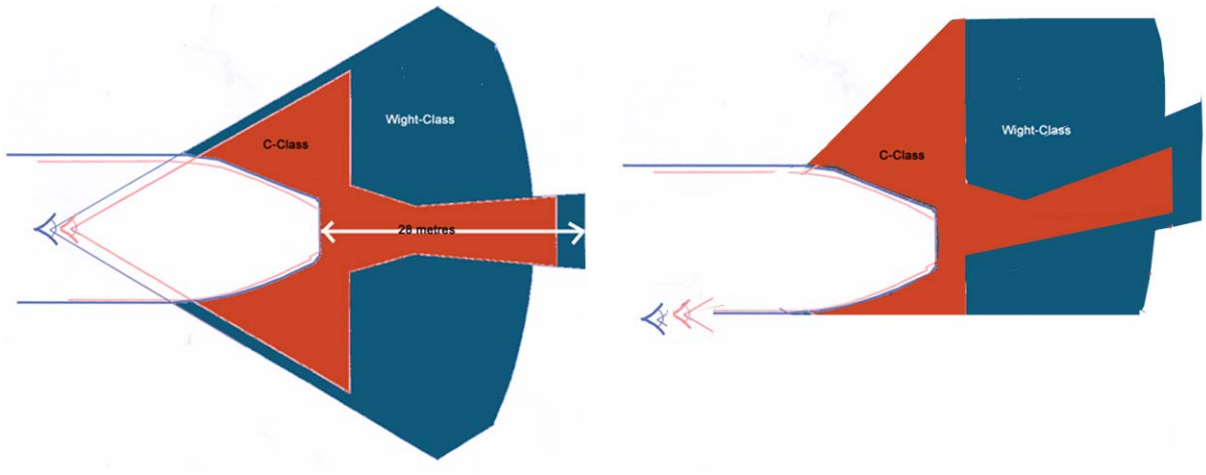

Figure 12 Comparison of Visible Water-Level from the Bridges (Centre and Beam)

While a canoe or small rowing dinghy will not be directly visible over most of this area; a large yacht (or at least its mast) will be visible.

Note that the view on the C-Class is quite cluttered and not helped by Wightlink's advertising attached to the rail ahead of the bridge.

4.6 Windage

Note that wind tunnel tests would be required to determine the effect accurately; the following is strictly "an artist's impression".

The following diagram indicates the wind shadow to leeward and turbulence to windward of the ferries at water level. It is based upon the wind shadow having a depth of ten times the height and the turbulence a depth of three times the height of the ferries. These are rules of thumb as is the shading showing the intensity of the effect.

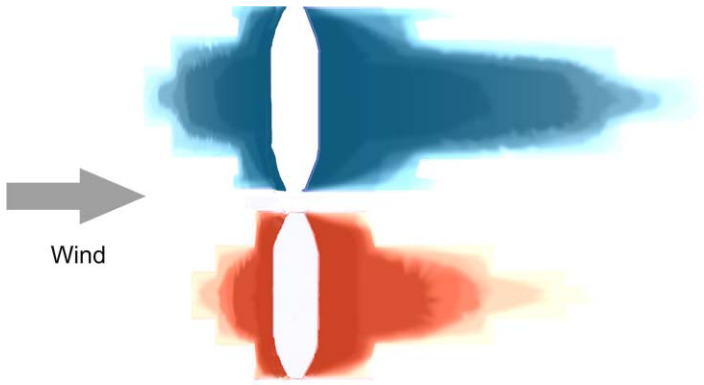

Figure 13 Windward Wind Turbulence and Leeward Wind Shadow (Artist's Impression)

Note that the Figure shows the disturbance areas for stationary ferries with a beam wind. The areas will be skewed depending on the speed of the ferry relative to the wind.

5 Underwater

Line diagrams have just become available in the BMT SeaTech report; however it has not yet been possible to perform a detailed analysis of the underwater shape.

The underwater shape of the W-Class is different from that of the C-Class. The end sections of the W-Class is cut-away, whereas that of the C-Class is rounded (see Picture 4, and Picture 3), the centre section of the W-Class is slab-sided, whereas that of the C-Class has an over-hang (see Figure 15). The W-Class has a central skeg extending the keel in either direction at its lowest point; this does not show up in the following diagram.

5.1 The Profile from Abeam

The underwater profiles of the two ferries are similar in area however the above/below water ratio is very different.

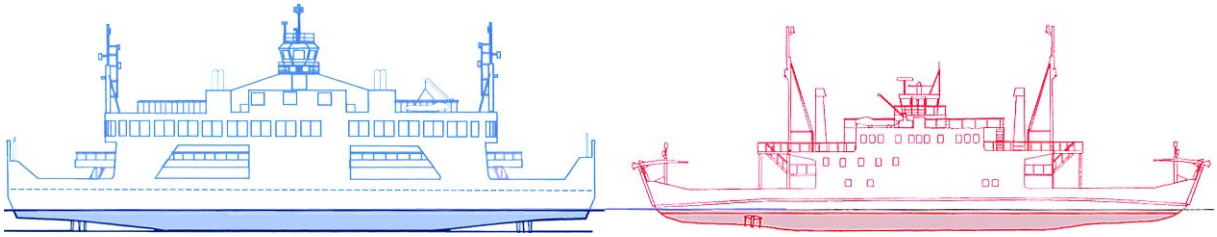

Figure 14. Underwater Beam Profiles

Comparison of Below-water Beam Profile Dimensions

		C-Class	W-Class	Difference
Lengths				
	Waterline	55.55 m	60.92 m	+ 9.7%
Draught				
	Operational	2.28 m	2.13 m	- 7%
	Maximum	2.28 m	2.3 m	+ 1%
Profiles at Operational Draught				
	Below Water (1)	104 m^2	101 m^2	- 3%
	Above/Below Ratio	3.08	6	+ 94%

(1) The propulsion units were excluded

5.2 The Cross-section

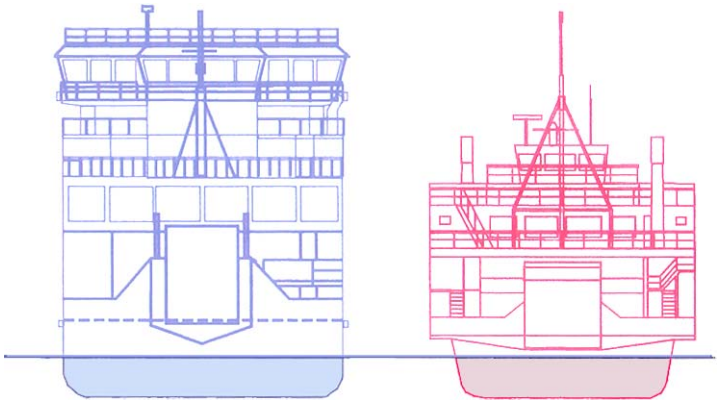

Figure 15. Underwater Cross-Sections

Comparison of End-on Profile Dimensions

		C-Class	W-Class	Difference
Beam				
	Waterline	55.0 m	61 m	+ 11%
	Flat Bottom	260 m^2	360 m^2	+38%
Draught				
	Operational	2.28 m	2.13 m	- 6%
	Maximum	2.28 m	2.3 m	+ 1%
Profiles at Operational Draught				
	Below Water	27 m^2	32 m^2	+ 18%

5.3 Propulsion Units

Over 60 years ago, the Lymington to Yarmouth ferries were the first double-ended ferry in the world to be driven by Voith Schneider propellers (also called "thrusters"). The propellers work by spinning and ejecting a jet of water in the desired direction; the ferries have no rudder. Information and an interesting demonstration of a working propeller is available on:
http://www.voithturbo.com/vt_en_pua_marine_vspropeller.htm.

Recently there has been concern about the damage that such propellers will do to the river. So, while this report is not analysing the propulsion of the ferries nor the effect on the environment, these details may be relevant.

Picture 2 Voith Schneider propeller

The size of the units for the W-Class can be obtained from the model number given on the Wightlink website. The information on the units on the C-Class was derived from the Rob Caledon plans, the code given in the Navigational Review and

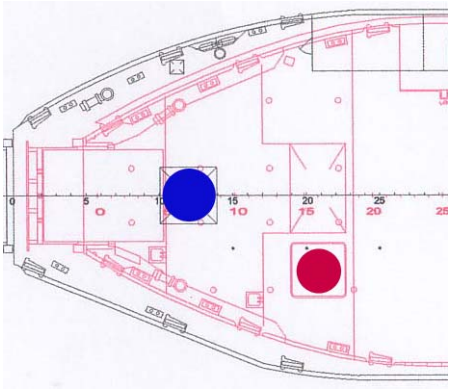

Figure 16. Propulsion Units Positions (Blue W-Class, Red C-Class)

Picture 3. Underside view of C-Class showing propulsion units

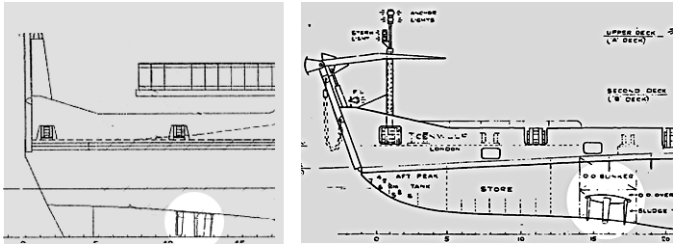

Figure 17 **W-Class Propeller** (HF Plans) **C-Class Propeller** (RC Plans)

Note that the skeg at the end of the W-Class appears not to have been fitted.

The blades of the W-Class will be fitted with end-plates to improve efficiency.

Comparison of Propulsion

		C-Class	W-Class	Difference
Voith Schneider Types		16R5	21R5/135s	
Propeller Sizes				
	Length of blades (1)	1.1 m	1.35 m	
	Diameter	1.6 m	2.1 m	
	Max input power each (2)	540 kw	815kw	
	Max speed (2)	670	700-1700	
	Gears (2)	1	2	
Engines (3)				
	Number	2	4	
	Power per engine	309-397 kw	550 kw	
	Total Power	618-793 kw	2200kw	
	Total Power delivered		1760 kw	
	Total power hp	800 hp	2360 hp	+ 195%
	Total power load for propellers		1630 kw	
Propeller Positions				
	from centre line of ferry	3.3m	0 m	
	from end of ferry	13.5m	7.9m	- 42%
	from nearest beam	2.7m	4.5 m	+ 67%
	tip above keel depth	0.3 m (4)	0 m	

(1). The length of blades on the C-Class was derived from the Rob Caledon plans and that on the W-Class from the Type Code..
(2). The propellers on the ferries are not standard. These figures are for the standard 1.6m and 2.1m diameter propulsion units.
(3). See notes in the Navigational Review section 3.1.1. and Wightlink comment below.
(4) Distance estimated from the Rob Caledon plan (see Figure 17) and the photograph of the underside of the C-Class Picture 3.

Wightlink's statement of 28/2/08 was:

"The four Volvo engines in a Wight Class vessel will have a maximum capability to deliver 550kW each. The Voith units will have the maximum ability to absorb 815kW each. Allowing for power loss in the transmission system, the engines will be rated to deliver 418kW each, which will produce a maximum speed in excess of 11 knots. At lower speeds less power is required, which will enable a vessel to run on three engines. This is intentional in that redundancy of engines will allow for maintenance work to be undertaken whilst a Wight Class vessel remains in service."

5.4 Displacement, Deadweight and Draught Variations

Displacement is important because, apart from indicating the weight of the ferries, it indicates the amount of water which must pushed out of the way in front of the ferry and which then returns after the ferry had passed.

Deadweight is defined as the displacement at any loaded condition minus the lightship weight. It includes crew, passengers, cargo, fuel water and stores. Lightship measures the actual weight of the ship with no fuel, passengers, cargo, water etc. on board.

Wightlink have stated that the three-fold increase in deadweight is "just the way it is". We assume that by this they mean that the Impact and Damage Stability Requirements require that

the underwater shape is as it is and the height of the vehicle deck is required by the regulations. This results by default in the deadweight.

The BMT SeaTech Phase 1 Report laid great emphasis on the fact that ferries are "volume" rather than "deadweight" carriers. However in fact deadweight could have implications for freight vehicle carrying capacity (see "An Analysis of Lymington-Yarmouth Ferry Capacity" on the Lymington River Association web site.)

Wightlink has stated that the W-Class will normally operate at a lesser draught than that of the C-Class. This is because the normal operational deadweight of the W-Class is expected to be lower than that specified in the plans. No figure is available for the normal working maximum deadweight or draft of the C-Class so the fully loaded figures have been taken.

Comparison of Draft

		C-Class	W-Class	Difference
Deadweight (1)				
	Operational	156 tonnes	215 tonnes	+ 38%
	Maximum	156 tonnes	330 tonnes	+ 111%
Drafts				
	Operational	2.28 m	2.13 m (2)	- 8%
	Maximum	2.28 m	3 m	+ 1.0%
Profiles at Operational Draught (2)				
	Above Water	304 m^2	606 m^2	+ 99%
	Below Water	104 m^2	100 m^2	- 3.6%
	Above/Below Ratio	2.9	6.1	+ 110%
	Ratio of sideways forces allowing for windshear	1	2.45	+ 145%

(1) Deadweight is defined as the displacement at any loaded condition minus the lightship weight. It includes crew. passengers, cargo, fuel water and stores. Lightship measures the actual weight of the ship with no fuel, passengers, cargo, water etc. on board.
(2) There have been some minor discrepancies in the figures quoted by Wightlink for the working draft of the W-Class.

5.5 Hull Interaction

The major interaction between two vessels passing beam-on is the hydrodynamic interaction between their hulls under the water. The W-Class and the C-Class have different underwater beams and shapes. If this interaction is critical, the W-Class will have to pass at a greater beam-to-beam distance in order to maintain the same or less underwater attraction. We have seen no tank tests or calculations evaluating this interaction. The following diagram shows the underwater difference.

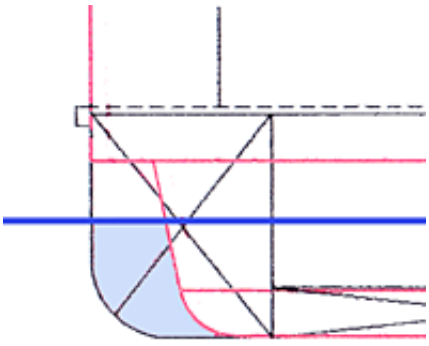

Figure 18 Underwater Comparison

6 Analysis of Size Increase

We have not sufficient information to analyse the increase in displacement of either ferry class. Wightlink have claimed that the increase is largely due to the need to satisfy modern safety requirements. This statement should be looked at in the context of the much larger physical dimensions of the ferry and its greatly increased vehicle capacity. Our enquiries elsewhere have suggested a much lower figure for the increase due to the new regulations.

The however it is possible to estimate the increase of the above-water dimensions of the W-Class:

- **The "Footprint"** is 19% greater than that of the existing ferries. It is necessary that the new ferries have to navigate the existing bends in the river. This is something the ferries proposed 15 years ago, could not do due to their significantly greater length. The use of the term "footprint" by Wightlink may have been slightly unfortunate; however the more accurate term "seagulls-eye view" might have had even more unfortunate connotations for passengers sunning themselves on the deck.
- **The Overall Length** has been increased: it is not clear why.
- **The Main Deck** has been raised has been raised to 2.3 m above the waterline. This means that it is 1.4 m higher at the ends and 0.6 m in the middle than the main deck of the C-Class, which is humped. Presumably this is due to the new safety regulation for RORO (Roll-On/Roll-Off) ferries. The average height of the gunwales above the deck is actually higher on the C-Class due to the humpback deck.
- **The Main Deck Enclosure** has been extended. This seems to have two benefits: it allows a longer mezzanine car deck with ramps and for the upper car deck to be supported. It also allows a passenger lounge to surround the upper car (or garage) deck.
- **The Upper Deck** accommodates the upper car deck and passenger lounge; on the C-Class the lounge is split between the mezzanine and upper deck. One benefit to Wightlink of the upper car deck (and the knock on effect on the passenger lounge) is to handle a mix of cars, cars with high loads on top, caravans, campers, minibuses, coaches and trucks at peak times. It is hard to believe that Wightlink have not anticipated the later addition of an extended mezzanine equivalent to the current upper car deck, for use when there is not a full load of high vehicles. (See the LRA Analysis of Lymington-Yarmouth Ferry Capacity report on the LRA web site.)
- **The Deck Houses** account for the remaining increase. They also add extra height to the bridge to give a better view over the extended foredeck.

Breakdown of Increase in Profile at Operational Draught

	Difference	
	Area Increase	**% of Diff**
Greater Length	21 m^2	7 %
Higher Main Deck	54 m^2	18 %
Main Deck Enclosure	98 m^2	32 %
Lounge/upper car deck	108 m^2	36 %
Deck Houses etc	21 m^2	7 %
Total Difference	302 m^2	100%

7 Pictures, of W-Class Under Construction

Photographs of W-Class under construction (from Wightlink website gallery)







Picture 4. Bow cross-section showing well for propulsion unit and asymmetry of hull shape

Picture 5. Bow section to be joined to that shown in Picture 2.

Picture 6. View showing the upper deck "superstructure".

Picture 7. End view

Picture 8 Side View