THINKING INSIDE THE BOX – DEVELOPMENT OF A MONOHULL FAST LANDING CRAFT

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SUMMARY

The UK Ministry of Defence (MoD) is planning to replace the existing Mk10 landing craft with a fleet of new Fast Landing Craft (FLC) capable of over-the-horizon surface assault. Challenging dimensional constraints governed by the requirement to operate from within existing UK amphibious support vessels, coupled with the high speed and heavy payload requirements necessitates an innovative solution. Furthermore, the craft must exhibit excellent beach stability to ensure that landing force capability can be off-loaded safely.

Following a detailed study of potential hullform solutions covering a range of basic and advanced forms, BMT has identified a novel monohull form as a potential candidate for future FLC technology. An extensive research and development (R&D) program has been conducted to assess the performance of three monohull variants, each exhibiting varying degrees of beach stability. The results have confirmed that a novel monohull form with inherent beach stability can meet the demanding performance requirements with reasonable levels of installed power.

This paper describes the design development and testing of the monohull FLC, and demonstrates how relatively simple monohull technology can be optimised to offer a novel solution by 'thinking inside the box'.

1. INTRODUCTION

It is a fundamental requirement that the future FLC must be designed to operate within the same footprint as existing Mk10 landing craft in order that the amphibious assault force can continue to operate from existing Landing Platform Dock (LPD) ships (Figure 1) such as *HMS Albion* and *HMS Bulwark*.

Figure 1: FLC integration with LPD

The requirement to operate from within an existing LPD provides a challenging set of dimensional constraints with regard to length, beam, draught and air draught. Furthermore, with the high speed, high payload and demanding seakeeping requirements, and the need to exhibit excellent beach stability, the design requirements are also very challenging.

However, a challenging set of design requirements does not necessarily require a complex design solution. Following a review of a wide range of hullform types, BMT has identified that a novel monohull, properly designed, can meet the complex design and operational requirements presented in Figure 2.

Fixed constraints on maximum dimensions		
- Maximum Length	30.0	metres
- Maxmium Beam	7.7	metres
- Maximum Draught (Loaded)	1.5	metres
- Maximum Air Draught	5.5	metres
High payload and high speed requirements relative to displacement		
Payload – 1 x Main Battle Tank (MBT)		
- Total deadweight	~ 90	tonnes
- Operating speed	> 21	knots
Payload – 4 x All Terrain Vehicles (ATVP)		
- Total deadweight	~ 65	tonnes
- Operating speed	> 27	knots

Figure 2: Table of design requirements

The philosophy of 'thinking inside the box' therefore refers not only to the literal implications associated with the box constraints of the LPD, but also the idea that a relatively simple solution can be developed to address what is undoubtedly a complex requirement.

The paper starts by describing the work that BMT initially undertook in developing a range of monohull FLC hullforms as part of an internally funded R&D study. The paper goes on to describe the further design development and model testing of the proposed solution which was carried out as part of a Design Solutions Study (DSS) for MoD.

2. KEY CONSIDERATIONS

2.1 HYDRODYNAMIC REQUIREMENTS

The current Mk10 landing craft demonstrate conventional 'pram' style monohull forms with a very low degree of deadrise, and with additional beaching strakes fitted to the hull bottom to offer adequate beach stability. The Mk10 hullform demonstrates a high degree of 'buttock flow' rather than the more preferable 'waterline flow' for higher speed vessels. As shown in Figure 3, the bow ramp of the existing Mk10 is hinged very close to the waterline in order to minimise the length of the ramp and reduce air draught. These features severely limit the speed capabilities of the Mk10, resulting in a maximum loaded speed of approximately 9 knots. Furthermore, with a wide, flat bow ramp the existing vessels are often subjected to heavy slamming loads in a seaway.

Figure 3: Conventional landing craft ramp design

At 27 knots, the FLC speed requirement is three times the speed capability of the current Mk10 landing craft. Figure 4 highlights some important hydrodynamic particulars including details of waterline length, displacement, primary hull coefficients and operating Froude number. It can be seen that the operating Froude number is very high relative to the displacement, and in the early stages of the FLC design development it was concluded that to achieve high speed operation, the vessel had to be designed as a lightweight (aluminium or composite) monohull to increase length-displacement ratio and minimise block coefficient as far as possible.

Length and displacement		
- Waterline Length	27.2	metres
- Displacement (MBT Load)	210	tonnes
- Length-Displacement Ratio	4.6	
Hull coefficients		
- Block coefficient	~0.7	
- Prismatic coefficient	~0.8	
Speed regime		
- Operating Froude number (27 knots)	0.85	

Figure 4: Principal hydrodynamic requirements

2.2 BOW RAMP INVESTIGATIONS

Another fundamental consideration of the hydrodynamic design development was the arrangement of the bow ramp. The requirement to unload an MBT over the bow of the vessel demands a very wide, flat ramp which is likely to suffer from severe slamming in head seas and limit the potential speed of the vessel. It is clear that the standard type of ramp as installed on the Mk10 would be impractical for high speed operations in a seaway. Consequently, bow ramp investigations were carried out to identify a number of solutions which would improve the seakeeping capabilities of a monohull FLC.

A range of existing ramp technologies were explored to identify those that could potentially be applied to FLC applications. Existing technologies such as bow visors, clam shell doors, bow ramp fairings and folding ramps were assessed with regard to a number of design considerations including:

- Calm water resistance
- Seakeeping performance
- Air draught limitations
- Spatial impact
- Beach stability

Bow visors, clam shell doors and bow ramp fairings were all considered to impact on the mission capability of the vessel, or require complex engineering solutions. A bi-fold ramp with its hinge point located far above the waterline was identified as the optimum solution to improve seakeeping at high speeds, whilst meeting all operational and dimensional constraints. Furthermore, folding ramp technology is already well proven in commercial applications, including landing craft.

3. INITIAL HULLFORM DEVELOPMENT

3.1 BACKGROUND

The initial monohull FLC hullform development formed part of an internal R&D study funded by BMT. The main focus of the R&D study was to develop a novel monohull within the fixed constraints presented in Figure 2, capable of speeds in excess of 27 knots, whilst maintaining reasonable seakeeping and beaching capabilities. The R&D was divided into two stages:

- Stage 1 – hydrodynamic development of suitable hullform options,
- Stage 2 – model testing to confirm calm water capabilities of the various options.

3.2 R&D HULLFORM DEVELOPMENT

3.2 (a) General Methodology

BMT had previously identified that a well designed conventional monohull vessel would meet the FLC calm water speed requirements. However, it was considered that such a vessel would have no beach stability and the seakeeping would be poor even in low sea states. Consequently, research was carried out to identify potential methods of achieving improved beach stability and seakeeping performance without significantly increasing powering requirements in comparison to a hydrodynamically optimised conventional monohull form.

It was considered that inherent beach stability could be built into the hull lines by using a tunnelled hullform, as opposed to adding large beaching strakes which would greatly increase vessel resistance. Better seakeeping performance could be achieved largely by having finer waterlines in the bow to reduce speed loss in waves, and by raising the bow ramp far above the waterline to minimise slamming occurrences. As part of the R&D study, three hullforms were developed, denoted 'Conventional', 'Hybrid' and 'Tri-bow'. Example sections for these hullforms are presented in Figure 5, Figure 6 and Figure 7 respectively.

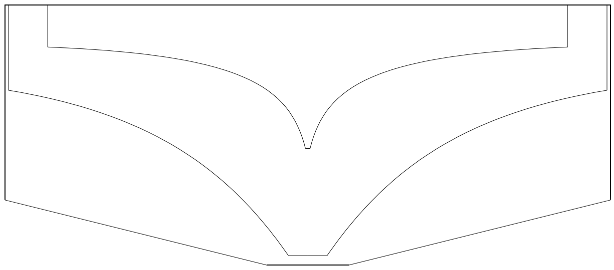

Figure 5: 'Conventional' monohull

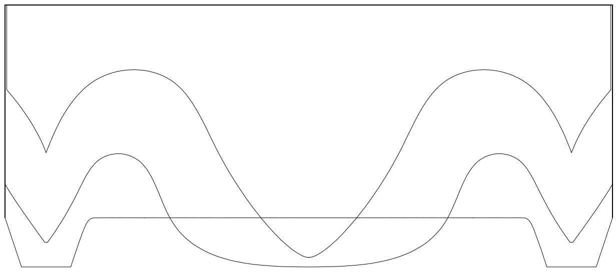

Figure 6: 'Hybrid' monohull

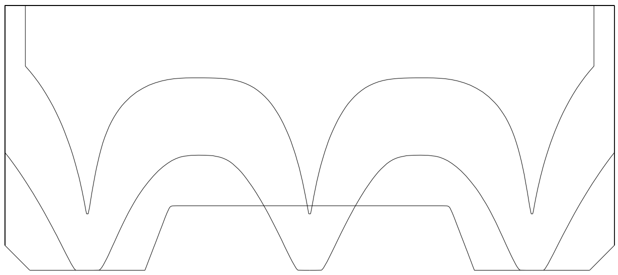

Figure 7: 'Tri-bow' monohull

The Conventional hullform was developed as a baseline design to demonstrate that a well designed, conventional monohull form could achieve 27 knots with reasonable powering levels. However, this hullform would offer no beach stability and poor seakeeping characteristics.

The Tri-bow hullform was vastly different from the Conventional monohull in that it had three narrow hulls in the forebody, with a raised cross deck structure forward, and a submerged cross deck structure aft. It was considered that the seakeeping of this vessel would be significantly better than the Conventional monohull due to the raised tunnel and significantly finer waterlines in the bow. The outboard hulls in the forebody would offer excellent beach stability.

The Hybrid hullform was a compromise between the two hullforms described above, but with rounded bilge geometry along the vessel length. The vessel is similar to the Conventional monohull in the forebody, but demonstrates a tunnel in the aft end similar to that of the Tri-bow. Whilst it was considered that beach stability would be poorer than the Tri-bow hullform, it would be an improvement in comparison to the Conventional hullform. The Hybrid hullform was also expected to perform reasonably well in waves.

It should be noted that in developing suitable hydrodynamic form options, the practical implications of incorporating certain features such as hull appendages, stern ramps and bow ramps were purposely disregarded during this initial design phase. Instead, it was considered that the first step should be to focus solely on the hydrodynamic optimisation of the hull, without being limited further by a range of additional design constraints, each of which could be addressed individually at a later stage.

3.2 (b) Hydrodynamic Optimisation

Taking into account limitations on longitudinal centre of gravity (LCG), a target sectional area curve and a target longitudinal centre of buoyancy (LCB) were identified using BMT's database of past model test data, providing optimised sectional area curve shapes and hullform coefficients for vessels of similar length-displacement ratio and operating Froude number. Having determined the likely optimum sectional area curve shape, key elements of the hullform design were considered such as maximising waterline length and reducing angles of entrance below the design waterline.

In designing a high speed, high payload vessel it is important to maximise waterline length as much as possible to increase length-displacement ratio and allow more flexibility in obtaining optimum hullform coefficients. Consequently, all three hullform variants were designed with a fairly steep stem profile in order to maintain waterline length, particularly as the vessel would trim considerably by the stern at high speeds. For vessels of this form, approximately 80% of the total resistance is due to wave resistance, with the remaining 20% attributable to frictional resistance. This highlights the importance of minimising displacement as well as maximising vessel length.

For the Hybrid and Tri-bow variants, the tunnel lines were developed such that the tunnel was as high as possible in the forebody, with a gentle gradient running aft towards the waterline. This was partially to minimise the effects of slamming, but also to allow turbulent air and water to flow as freely as possible between the centre hull and the side hulls. It was expected that these design features would combine to offer a solution capable of operation at high speed in a seaway.

Whilst all three hullform variants were very different in appearance, each hullform was designed with identical principal particulars and hydrostatic particulars including length, breadth, draught, primary hull coefficients, LCB position and sectional area shape. The conventional hullform could therefore be used as an effective baseline comparison for the other hullforms exhibiting varying levels of beach stability.

3.3 R&D MODEL TESTING

The three hullform variants described in Section 3.2 were tested in calm water at a model scale of 1:15. The tests were conducted by BMT at the Haslar ship tank in Gosport, UK.

The models were each tested with a deadweight of 65 tonnes (ATVP load) and at level trim. Runs were performed at six speeds ranging from 12.5 knots to 27 knots, in order to build an accurate resistance curve for each vessel.

The Conventional and Hybrid variants were found to demonstrate very similar resistance characteristics across the range of speeds. At speeds above 16 knots the Tri-bow variant demonstrated resistance values around 7% higher than the Conventional monohull, as shown in Figure 8. However, it should be noted that the Tri-bow is inherently stable on a beach, whereas the Conventional monohull and the Hybrid monohull would require additional appendages to ensure adequate stability. Such appendages are known to considerably increase vessel resistance.

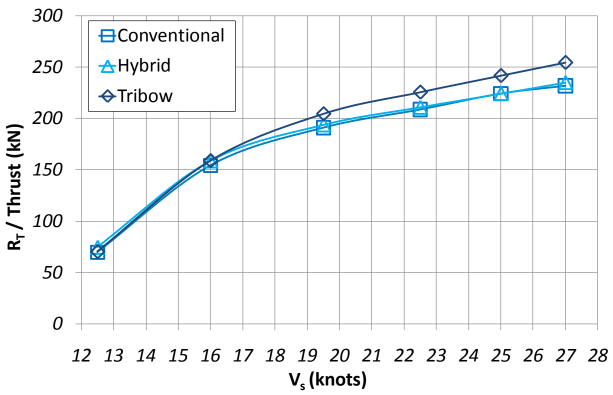

Figure 8: Full scale resistance comparisons

The model tests confirmed that each of the three monohull FLC hullforms was capable of achieving 27 knots in calm water using approximately 6 MW of installed power whilst carrying a deadweight of 65 tonnes. This level of installed power can be achieved using a number of conventional machinery options.

It was concluded that with some small variations to the hullform design, the Tri-bow form could be optimised to offer similar performance characteristics to those of the other two forms. It was also considered that the Tri-bow hullform would offer the best seakeeping performance of the three variants due to the fine waterlines and high tunnel in the forebody.

The Tri-bow monohull was therefore selected for further optimisation as part of a Design Solutions Study for MoD, funded by Defence Engineering & Support (DE&S).

4. DESIGN SOLUTIONS STUDY

4.1 BACKGROUND

The R&D study had identified that a novel lightweight monohull could be developed to offer a potential solution for future FLC. The work subsequently undertaken in the DSS was carried out to develop the novel Tri-bow monohull concept to a stage where the risk associated with a potential monohull FLC design was minimised. The DSS was divided into the following stages:

- Stage 1 – design development of the Tri-bow hullform,
- Stage 2 – model testing to confirm the performance of the optimised hullform in calm water and in waves.

4.2 DSS HULLFORM OPTIMISATION

4.2 (a) Background

To build confidence levels and minimise any risk associated with the design of a lightweight monohull FLC, further development of the concept was undertaken to ensure that the vessel would meet the requirements of relevant classification societies and naval authorities, including:

- Machinery selection
- Structural design
- Hull lines development and optimisation
- Assessment of ballast requirements
- Intact and damaged stability analysis
- General arrangement development
- Model resistance and seakeeping tests

4.2 (b) Machinery Selection

Following a review of a range of machinery options, two suitable options were identified using *MTU* diesel engines and *MJP* waterjets, each supplying a total of around 6 MW:

- 2 x *16V 4000 M93* engines + 2 x *J850* waterjets (total power = 6.2 MW / total weight = 19.8 tonnes)
- 3 x *16V 2000 M94* engines + 3 x *J750* waterjets (total power = 5.8 MW / total weight = 10.2 tonnes)

It should be noted that whilst both engine options are based around a high performance rating, typical operating hours for the FLC are very low at approximately 500 hours per year.

Although significantly heavier than the three engine option, the two engine option offered a higher installed power than the three engine option, and it was expected that a more efficient hullform could be developed around the two engine layout by increasing the waterline length in-between the waterjets. However, it was generally accepted that the three engine option offered clear advantages over the two engine option, including:

- Lower machinery mass (a total weight saving of almost 10 tonnes),
- Excellent level of redundancy (can continue to operate even following the loss of two shafts),
- Lower cost (a cost saving of over £0.75M per vessel)
- All three engines located below main deck structure,
- Smaller machinery items allows excellent all-round access for maintenance and repair and a shorter engine room (as shown in Figure 9).

Whilst the three engine option was the preferred option at this stage, it was proposed that further development and model testing should be carried out for both the two engine option (denoted 'Variant A') and the three engine option (denoted 'Variant B').

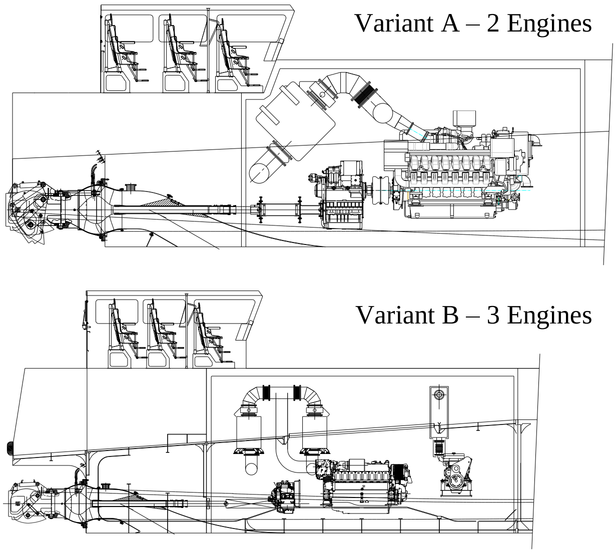

Figure 9: Machinery arrangements

4.2 (c) Structural Design

From an early stage in the design development it was evident that a lightweight construction material was required. Steel construction would have a significant impact on vessel weight and subsequently on the speed capabilities of the vessel. For the DSS, aluminium construction was selected. It is not uncommon for high speed craft to be constructed from aluminium, although with unusually high payload requirements and the requirement to take to the ground, it was clear that the structural design development would be an important consideration in the development of the monohull FLC.

Structural arrangements and preliminary scantlings were developed using Lloyd's Register Special Service Craft (SSC) Rules, and a preliminary global structural analysis was undertaken. Figure 10 illustrates a typical stress plot for the beached condition when unloading an MBT.

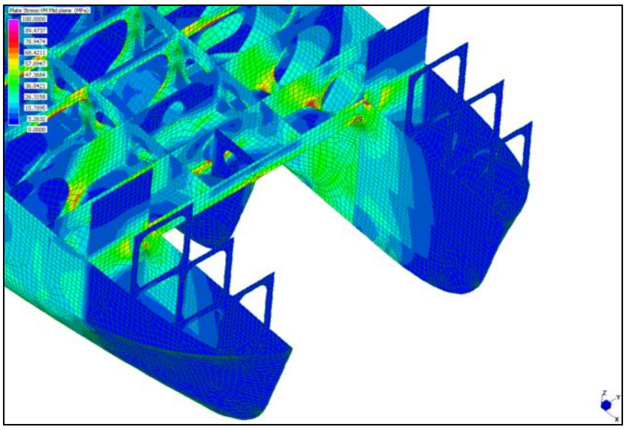

Figure 10: Typical stress plot from global analysis

The principle structure was developed to a level where a high degree of confidence was achieved in the structural weight estimate, in addition to the knowledge that the structure was suitably designed for beaching and docking operations.

4.2 (d) Hull Lines Development and Optimisation

Preliminary hull lines for Variant A and Variant B had already been compiled to allow much of the initial DSS work to be undertaken. However, further hydrodynamic optimisation was required prior to model testing. This section summarises the methodology behind the further development and optimisation of the Tri-bow monohull and describes the principal differences between Variant A and Variant B.

As discussed, fixed constraints on principal dimensions such as length, beam and draught coupled with extremely high deadweight requirements result in a very high block coefficient and displacement for a vessel of this speed. To achieve the best possible performance in calm water and in waves, a number of key design ideas were implemented, including:

- Minimising calm water resistance by maximising waterline length (e.g. through use of a steep stem profile and use of an additional 'box' at the transom for the two engine variant),
- Minimising calm water resistance by reducing displacement (e.g. use of lightweight materials, reducing weight of keel plating by minimising beach contact area),
- Minimising calm water resistance by reducing waterline angles of entrance in the forebody,
- Maximising performance in waves by raising bow ramp hinge point far above the waterline to reduce slamming and resulting speed loss.

It should be noted that whilst the Tri-bow hullform demonstrates three bow forms in the forebody, the tunnelled areas in this region reduce in depth (moving aft) until the 'wet deck' is fully submerged. Consequently, the vessel can be considered as a monohull because there are no clear tunnels extending throughout the length of the hull. Air cannot flow freely from the bow to the stern beneath the hull, and consequently a turbulent mix of air and water is generated beneath the bow ramp.

To reduce the turbulent flow of water into the tunnelled region, a degree of asymmetry was introduced into the outer hulls to direct as much water as possible outboard, rather than into the turbulent flow beneath the bow ramp. The vertically sided inboard shell in the forebody provides an ideal arrangement for the ramp to be lowered and suitably supported, whilst any remaining turbulent flow provides a degree of damping should slamming occur. The asymmetry in the outboard hulls can be seen in Figure 11. Figure 12 shows the shape of the design waterlines for each of the Tri-bow hull variants.

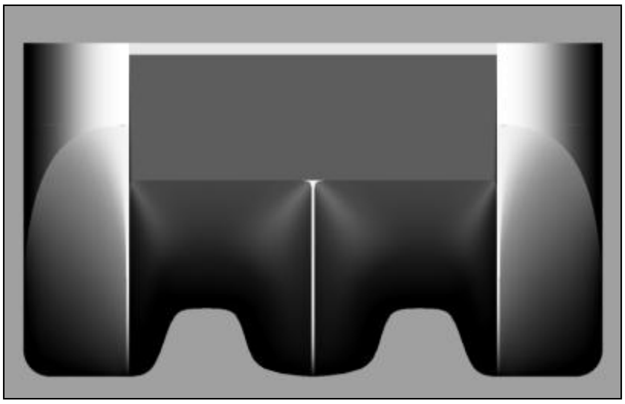

Figure 11: Tri-bow hullform viewed from bow

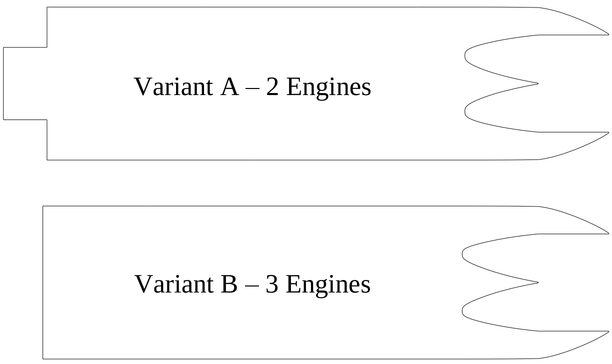

Figure 12: Illustration of design waterlines

Figure 12 also shows a difference in hull geometry at the aft end. Variant A has an additional transom box which was added between the two waterjets in order to increase the waterline length and subsequently increase the length-displacement ratio. With a central waterjet, Variant B cannot be designed with such stern geometry.

It should be noted that due to the differences in machinery weights between the two variants, Variant B was designed with a displacement 10 tonnes lighter than that of Variant A at the same design draught.

Following the hull lines optimisation described above, initial DSS work was reviewed and updated as is typical in the 'ship design spiral'.

4.2 (e) Ballast Requirements

The requirements for seawater ballast were reviewed based on a number of potential loading conditions ranging from the lightship condition to the heaviest (MBT) loading condition. In assessing the seawater ballast requirements, the air draft limitations, operating draughts and trim of the vessel were all taken into account.

The loading and ballasting calculations showed that there was no requirement for a seawater ballast system in order for the vessel to remain within the draught and air draught limitations. In the MBT condition, the MBT can be positioned to achieve level trim depending on the fuel load of the vessel, with suitable tie-down arrangements designed accordingly. In the ATVP conditions there is no scope to move the vehicles longitudinally to change vessel trim. Consequently, without a ballast system the vessel demonstrates approximately 1 degree of static stern trim. In the light seagoing condition the vessel demonstrates approximately 2 degrees of static stern trim. As discussed in Section 4.3 (a), aft trim is favourable in these conditions from a performance perspective.

4.2 (f) Intact and Damaged Stability

A full intact and damaged stability analysis was carried out based on the requirements of DefStan 02-109 Part 1. Since the vessel is a high speed vessel some additional requirements of the IMO High Speed Craft (HSC) Code 2000 were also considered.

The vessel was found to demonstrate good intact and damaged stability characteristics, meeting the criteria with only some minor tailoring of the requirements. Furthermore, the vessel is capable of remaining afloat in all conditions following a significant level of bottom raking damage which, for fast landing craft, is a highly desirable attribute. An illustration of the worst cases of raking damage is presented in Figure 13.

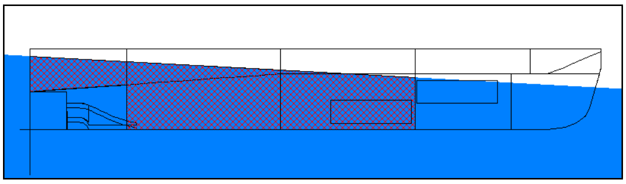

Figure 13: Worst case of raking damage

4.2 (g) General Arrangement

General arrangement drawings for each variant of the monohull FLC were initially developed at a basic level to demonstrate capabilities with regard to payload and space arrangements, including accommodation and wheelhouse areas. Following the model tests described in Section 4.3, the general arrangement for Variant B was developed further at concept level as shown in Figure 14.

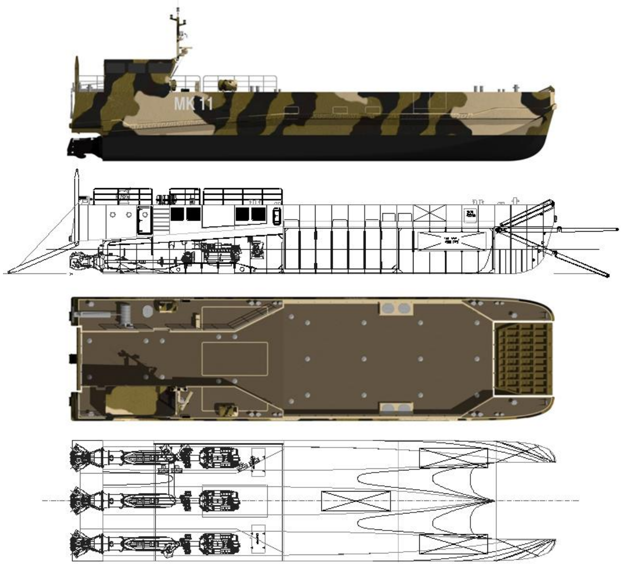

Figure 14: Monohull FLC general arrangement

4.3 DSS MODEL TESTING

4.3 (a) Calm Water Resistance Tests

In order to confirm the speed capabilities of the vessel in calm water, a series of resistance tests was carried out on both hull variants at a model scale of 1:10. The tests were conducted at the Haslar ship tank in Gosport, UK.

The tests demonstrated that in calm water, both variants were capable of achieving speeds in excess of the requirements. However, Variant B was found to offer better calm water performance and significantly higher cavitation margins, even with operation on two engines. Based on the results of the calm water resistance tests, Variant B was identified as the favoured option, particularly given the inherently high level of redundancy and its ability to continue operation at high speed following the loss of one shaft.

A small amount of stern trim was found to offer the lowest hull resistance in the light and ATVP conditions. Level trim or a small amount of bow down trim was found to offer the lowest resistance in the MBT condition. However, the effects on vessel resistance of changing vessel trim were noted as being very small, indicating that optimising the longitudinal distribution of payload would not significantly influence vessel resistance. This also suggests that the hullforms have been designed with close to optimum LCB positions.

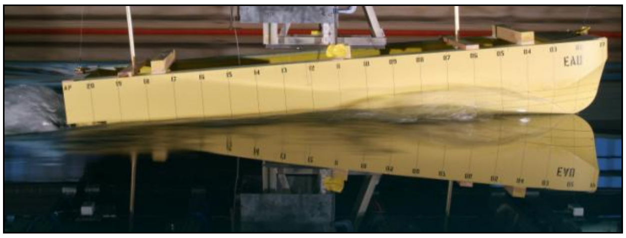

Figure 15: Model calm water resistance tests

Figure 16 compares the full scale resistance of the optimised Tri-bow monohull with the original Tri-bow and Conventional monohulls. At 27 knots it can be seen that the optimised Tri-bow hullform demonstrates equivalent resistance to the Conventional monohull, indicating that the optimisation techniques described above had a beneficial effect on calm water performance.

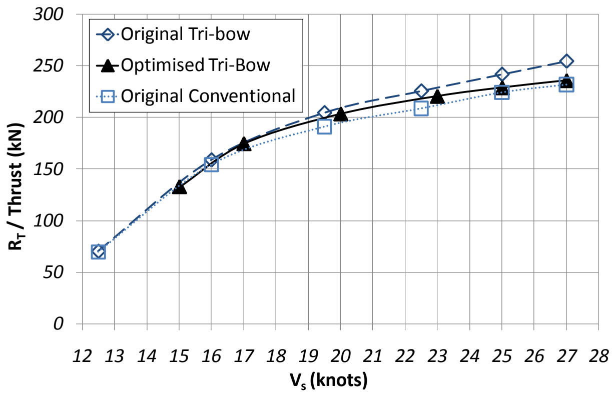

Figure 16: Full scale resistance comparisons

4.3 (b) Seakeeping Tests

In order to confirm the speed capabilities of the vessel in waves and to measure the seakeeping performance of the vessel in terms of roll motions, pitch motions, vertical velocities, vertical accelerations and slamming occurrences, a series of free running, self-propelled seakeeping tests were carried out on both hull variants at a model scale of 1:12. Tests were conducted in sea state 3 (SS3) and sea state 4 (SS4) in head and bow quartering seas, at 24 and 28 knots. The tests were conducted at the Haslar ocean basin in Gosport, UK (Figure 17).

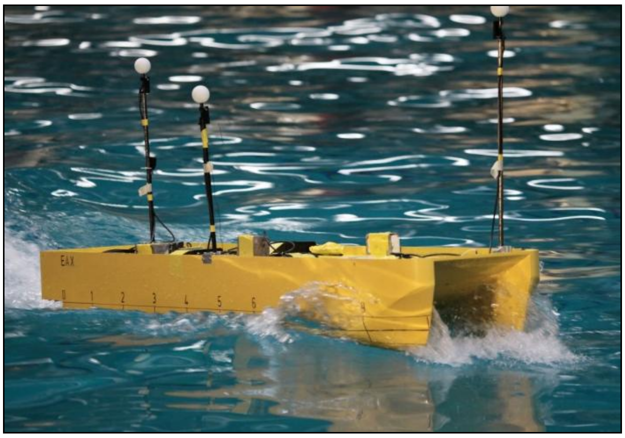

Figure 17: Model seakeeping tests

The tests demonstrated that in SS3, both variants of the monohull were capable of achieving speeds in excess of the requirements, with approximately 1 knot of speed loss in seas of up to SS4. Variant B was found to offer marginally less speed loss in waves, and therefore remained the favoured variant.

The roll, pitch and vertical acceleration measurements were generally found to be good when assessed against commonly accepted operational limitations, particularly in SS3. Due to the slightly heavier displacement, Variant A demonstrated marginally lower motions overall. However, differences in motions between the two variants were very small. Figure 18 shows measured root mean squared (RMS) vertical accelerations at the aft perpendicular (AP) and at the LCG. It can be seen that the measured values in head and bow quartering seas are in the order of 0.1g at 24 and 28 knots in SS3. These levels of vertical acceleration are within long term crew tolerance limits according to Payne, 1976.

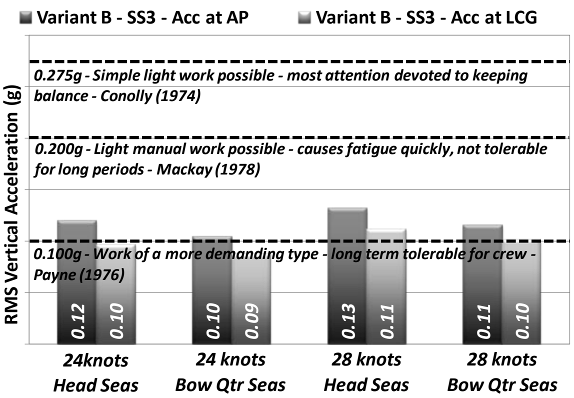

Figure 18: Measured RMS vertical accelerations

Slamming measurements were taken on the underside of the bow ramp based on a slamming threshold of 100 $kN.m^{-2}$. In head seas (SS4), at the centre of the bow ramp an average of 8 slams per 100 waves was recorded for Variant A and 11 slams per 100 waves was recorded for Variant B. The number of slams is considered to be reasonable for a 30 metre vessel operating in SS4. Variant B demonstrates marginally more slamming occurrences than Variant A as may be expected for a lighter vessel.

5. SUMMARY OF DESIGN DEVELOPMENT

Throughout the latter stages of the DSS, the three engine option (Variant B) was confirmed as the superior option. The key advantages over the two engine option are as follows:

- Higher speed capabilities in calm water
- Less speed loss in waves (in both SS3 and SS4)
- Considerably greater redundancy (can still operate following the loss of two shafts)
- Greater cavitation margins (even following the loss of two shafts)
- Lower lightship weight (10 tonne difference in propulsion system weights)
- Easier engine access and maintenance (more space in engine room)
- Easy engine removal (the LPD gantry crane can be used to replace engines at sea if necessary)

Key benefits of using a monohull hullform for FLC applications are as follows:

- Simple to construct
- No complex structures – folding ramp technology already used in a number of applications
- No complex machinery systems – low cost, easy maintenance
- Excellent level of redundancy – can maintain high speed operations following the loss of one shaft and low speed operation following the loss of two shafts
- No ballast system required – loading arrangements have been developed to meet operational limitations on draught in all conditions without ballast water
- Large cargo deck area – excellent access to and from vehicles on cargo deck
- Excellent beach stability – monohull is inherently stable (no need for additional beaching appendages)
- Good stability characteristics – vessel is capable of remaining afloat following significant levels of one compartment, two compartment and bottom raking damage
- Good seakeeping characteristics – motions are generally within recognised limits of operation, even in higher sea states

6. CONCLUSIONS

This paper has described the design development and testing of a novel monohull fast landing craft (Figure 19). The design has been developed to a stage where a high level of confidence has been achieved in the ability of the vessel to fulfil a potential role as a future FLC.

The paper has demonstrated that through the application of traditional naval architecture design techniques and ‘thinking inside the box’, relatively simple monohull technology can be optimised to offer an innovative solution to a challenging set of requirements.

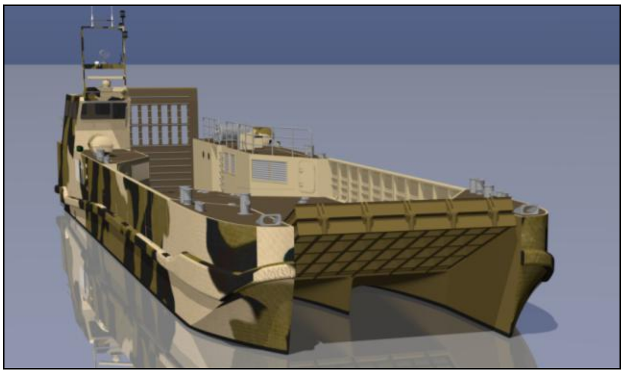

Figure 19: BMT’s patented monohull FLC

7. AUTHORS' BIOGRAPHIES

Rob Sime holds the current position of Naval Architect at BMT Nigel Gee Ltd. He is responsible for a wide range of naval architectural duties from the concept design stages through to the detail design stages, including hull lines development, stability calculations, performance predictions, model testing and sea trials supervision. Rob was heavily involved in the monohull FLC R&D and was Project Manager for BMT Nigel Gee during the subsequent DSS.

Ed Dudson holds the current position of Technical Director at BMT Nigel Gee Ltd. He graduated from the University of Southampton in 1990 and joined Nigel Gee and Associates the same year where he has worked continuously with the exception of a year's sabbatical in MARINTEK. He is a Chartered Engineer and Fellow of the Royal Institute of Naval Architects. Ed was Project Director for BMT Nigel Gee during the monhull FLC R&D and the subsequent DSS.

Dr Shane Amaratunga holds the current position of Senior Principal in the Naval Architecture Department at BMT Defence Services Ltd. Previously, Shane was Director of BMT Fluid Mechanics. He has been involved in a variety of concept and design support projects in the UK and overseas. Shane was Project Manager for BMT Defence Services during the DSS.