PO.ID 145

WFSV Through Life Cost Reduction by Marine Design of a Modular Interior

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EBDIG-WFSV

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Abstract

Marine Design is an holistic design process with a strong focus on the end users as well as stakeholders in the design process, based on the principles of Industrial Design. Effective Marine Design requires a multidisciplinary design team of Naval Architects, Industrial Designers, Human Factors specialists, environmental psychologists and interior designers.

Marine Design has a focus on technical concepts, products and processes, as the understanding of product life cycle is fundamental to the design for manufacture (DFM) of vessels or any other product in order for it to become a market leader. Marine Design encompasses the engineering of objects, usefulness as well as usability, market placement, and other concerns such as seduction, psychology, desire, and the emotional attachment of the user to the object.

This paper reports on a Marine Design approach to the development of a Wind Farm Support Vessel interior using a modular construction system. The modular system was specifically developed to be fitted in hours, whereas conventional fitting approaches currently take days. This design innovation facilitates adaptability, whereby the interior of a vessel can be changed to another use within a day, giving the operator vessel flexibility and extended operating life.

Introduction

Marine Design is an holistic design process with a strong focus on the end users as well as stakeholders in the design process, based on the principles of Industrial Design. In contrast to Industrial Design, Naval Architecture is about addressing a design specification. The most important part of the Marine Design (Industrial Design) process is reaching a well informed design specification. Effective Marine Design requires a multidisciplinary design team of Naval Architects, Industrial Designers, Human Factors specialists, environmental psychologists and interior designers. The start of the marine Design process is understanding the personas and needs of the end user. The aim of Marine Design is to improve the aesthetics, human factors and functionality of a vessel or system, and its' marketability. The role of a Marine Designer is to create and execute design solutions for problems of form, usability, ergonomics, marketing, brand development, and sales. Based on the principles of Industrial Design, the objective of which is to study both function and form, and the connection between product (vessel or system), the user and the environment.[1]

In the WFSV market design generations and variations are evolving so quickly that there are no DFM activities being undertaken, with the exception of a few yards. Due to vessels being reinvented from one model to the next it does not allow production learning to develop and most vessel builds suffer from technical creep incurring unforeseen costs. All of these factors are causing yards to go into liquidation or put prices up to cover inefficiency. The latter is a dangerous strategy since; once the perplexing number of vessel designs on the market start to consolidate to a fewer number of designs the companies that are not competing on product quality and driving costs down are going to go bust. Over the last few years in the UK out of 10 WFSV builders, 5 have gone bust, 2 have been rescued, with only 3 maintaining business as normal. In basic terms 70% of the UK productive capacity has or will no longer exist, while the market demand continues to grow. The challenging competition with instabilities of the market in terms of regulation within the market, require vessel designs to have and maintain a strategic advantage over the competition.

Whilst Naval Architects are qualified in the design of vessel hull and structures, the skill sets required for design for manufacture, interior design, fit out and human factors are a completely separate subject and not available in most Naval Architect practices or Boat yard design departments due to traditional business models. Therefore to achieve strategic advantage they should engage in the multidisciplinary holistic design practice of Marine Design. An integral part of which is the implementation of a model for vessel strategic advantage. Before any design or manufacture can start on any product there needs to be a robust process for the determination of the specification. The wind farm industry is a good example of how the specifications have changed over a short period of time and increased the number of stakeholder interests. To the point that vessels less than 6 years old are technically redundant and being laid up. At the core of the KPM model for vessel strategic advantage shown in Fig.1, is the Design Value Proposition (DVP) for the charter company. [2]

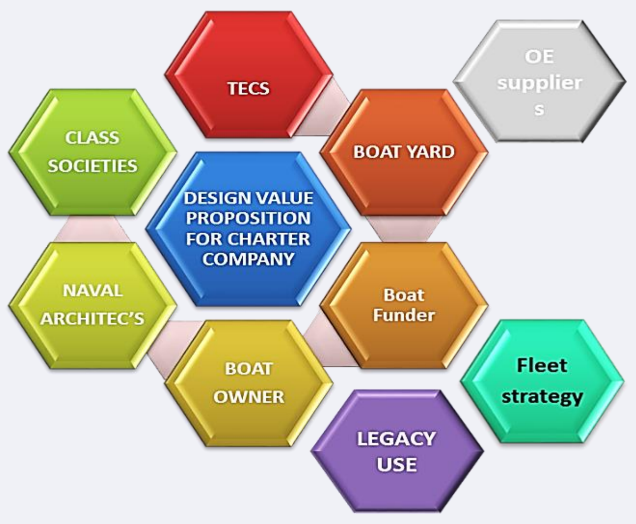

Figure 1:KPM model for vessel strategic advantage

Figure 2:KPM Model for Competitive Advantage

Whilst the vessel owner is the initial customer they still have a series of stakeholders that must be satisfied for the design to be viable in the market who are the charter companies. For example; consideration and importance of the criteria need to be determined for the following: the boat owner, the boat funder, the naval architects, the class societies, the technicians and the boat yard. The second tier of the model includes the OE suppliers and most importantly the legacy use of the vessel. The importance of having a methodology is vital since if any one of these criteria are ignored then the vessel design will be suboptimal and as a consequence the financial success of the project will be at risk. For example; the boat owner may choose not to class the vessel which restricts its operational capability, which in turn compromises the ability to win contracts and make repayments to the vessel funder. In the worst case if the boat owner has to liquidate its vessel asset, does it have a market value or a legacy use or will it be technically obsolete. Furthermore OE suppliers need to be considered strategically since if they go bust will the aftermarket service and availability of spares leave the vessel inoperable. These issues show the connectivity of the stake holders. Techno-economic forecasting is an essential tool to develop a robust informed future market scenarios resulting in financial success. The future market scenarios of both the offshore wind and the oil & gas sectors have been reviewed in the introduction.

Techno-economic forecasting facilitates strategic advantage requirements of specifying the vessels type and its position in both the current and future market. After which the competitive advantage has to be determined. The KPM model is shown in Figure 2. Once the vessels size and type has been determined from the strategic point of view, the owner or designer needs to consider asset adaptability and how the asset life can be extended to deliver optimum payback. For example ; questions that may be asked that influence this pivotal decision process may include ; what if I only get a 4 year contract but the vessel finance is over 10 years?; what if the day rate drops due to new technology vessels with lower operating costs?;what if the politics change. These issues could truncate the intended operational use of the vessel, informed by the techno-economic forecasting a scenario for other uses of the vessel would be developed. [3]

Design For Manufacture

The practice of modularity and standardisation in vessel construction is nothing new. All of the techniques described in this paper draw upon practices that have been used in the Construction, Rail, and Automotive industries for the last 30 years. This paper shows how the use of digital technology and basic manufacturing practice can be used successfully on small batch vessel production. The irony is that this practice is Knowledge based and not a cost based activity, but can significantly increase productivity and competitive advantage. A multi-industry study of companies that have instigated design [4] for manufacture and assembly programmes has reduced production costs by 30% and in the marine industry a 30:1 return in cost saving at the production stage for expenditure on design. This level of practice has eluded the marine industry, which is 30 years behind most other industries.

The understanding of product life cycle is fundamental to design for manufacture (DFM) of vessels or any other product in order for it to become a market leader. Due to the small numbers of the, same vessel, traditionally made there has been little or no effort made in design for manufacture. The general rule is that 80% of the product cost is fixed at design stage (See figure 3) and as such these costs cannot be influenced at build stage. The situation is exacerbated in the WFSV market since design generations and variations evolve so quickly that there are no DFM activities being undertaken, with the exception of a few yards. Due to vessels being reinvented from one to the next it does not allow production learning and most vessel builds suffer from technical creep incurring unforeseen costs.[5] A multi-industry study of companies that had implemented DFM practices proved to have an average reduction in production costs of over 30%.[6]

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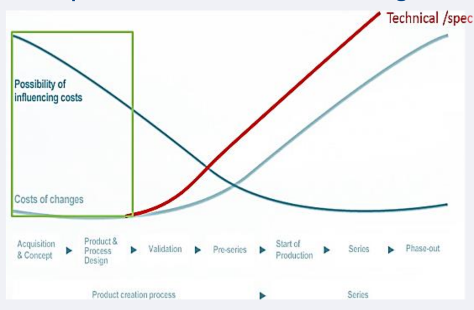
Figure 3: Cost influence at design

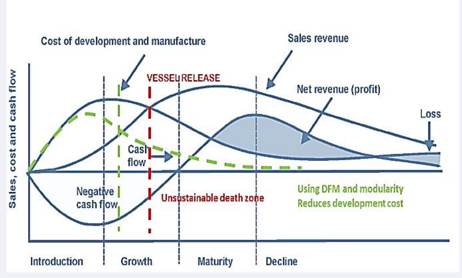
Figure 4: DFM influence on cost and cash flow

Using design for manufacture 80% of the costs could be influenced and controlled at the design stage. In basic terms 70% of the UK productive capacity has or will no longer exist. The reason for this decline is explained by Figure 4. Due to the lack of DFM the cost of development and manufacture of the vessel creates negative cash flow. [7] In effect, with the wide variety of designs each vessel is a prototype and this results in a loss at the end of production and vessel release. The reality is that yards have 2 unique designs going through production, followed by further unique and prototype effective vessels. At the release of each vessel there is a negative cash flow . With multiple new vessels, these losses are covered by the deposit from new vessel signings and this perpetuates until the scrolled forward losses cannot be sustained any further. However, this situation can be eliminated by controlling the 80% cost at design stage and using modularity and DFM to change the shapes of the curve and reduce or eliminate the negative cash flow by bringing forward the release date in line with stage payments.

For modularity to work it needs to have a defined infrastructure and foundation from which to build upon. Special structural track has been developed to which pre-cut flooring can be inserted between the track and clamped down with the surface rail (Figure 5). This system allows complete floors to be laid down within a day. The same approach is used on the ceiling with KPM Sky Trac (Figure 5). KPM marine developed a service skirt system that can be used in conjunction with wall boards (Figure 6). This technique has been used in trains and planes for many years and gives the benefit of service routing being able to be undertaken with the whole vessel fitted out, and the obvious benefit of access for service or electrical additions. The key to the speed of the installation of wall panels is the use of specially designed aluminium extruded profiles to cover all jointing types that may be required (Figure 7). The panels are supplied to the vessel numbered and pre-cut to suit, including window voids.

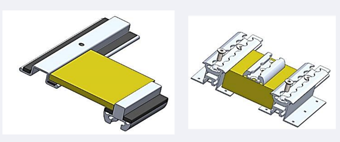
Figure 5: Floor and ceiling system

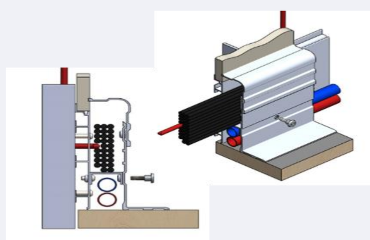
Figure 6: Electrical service trunk

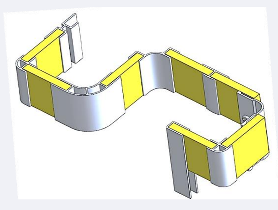
Figure 7: Wall panels systems

Initial Design Concept

From dialogue with the client the GA shown in Figure 8 was developed as a 3D basic rendered CAD model shown in Figure 9, to enhanced the visual communication of the design proposal with the client. The use of the DHMs (Digital Human Model) enables the ergonomics of the initial design concept to be assessed as part of the design process.

The UCD approach identified the need for: toilet; shower; changing facilities; kitchen; communal eating area; personal storage space. The use of lockers and an innovative design of personal storage space in the base of the motion seat pedestal addressed the individual storage space requirement. The implementation of interior design offers the technicians a positive and engaging experience that goes far beyond the application of UCD and engages in emotional design.

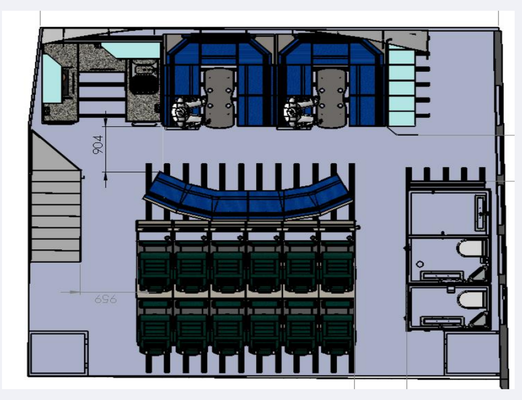
Figure 8: Plan view of crew cab (lower floor)

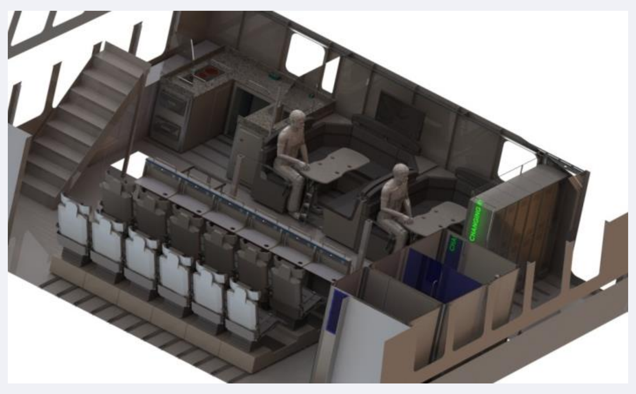
Figure 9: Rear 3/4 view of crew cab (lower floor)

The modular interior track system layout was designed to facilitate the flexibility of the vessel to serve the needs of clients for the both offshore wind sector and offshore oil & gas sector. The GA layout was modified to carry 28 crew on motion seats for Oil & Gas crew transfer, shown in Figure 10, with the number of toilets being increased to three to reflect the increase in technician numbers. Due to the modular nature of the interior, this refit could be completed within half a day giving the vessel significant operational flexibility. The rear ¾ view is shown in Figure 11.

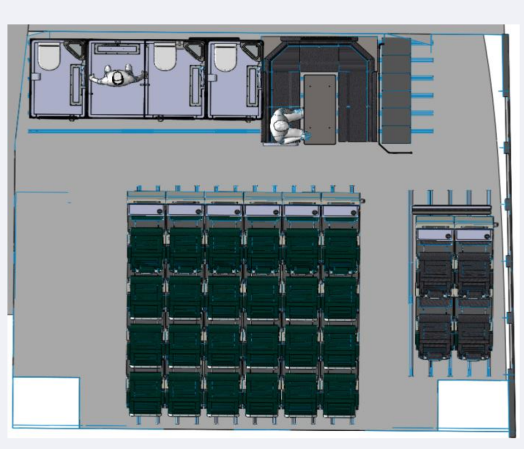
Figure 10: GA of layout for Oil &Gas crew transfer

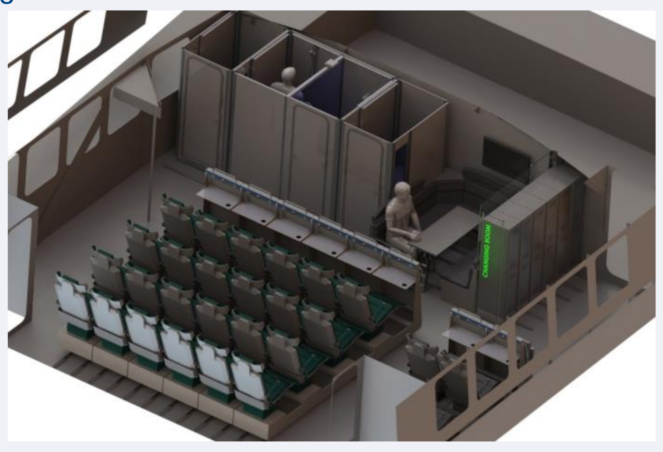
Figure 11: Rear 3/4 view layout for Oil &Gas crew transfer

Interior Design

The interior design process is an engagement in Design-Driven Innovation to give the interior the design meaning of a luxury motoryacht or premium seating area on a passenger ferry. The technology innovation is the application of the KPM modular interior system and the principle of DFM, also the use of lighting and material technology from high end luxury interior and motoryacht design. The emotional design approach to the interior builds upon the sensual experience of a luxury motoryacht, with cream leather seats on white frames and the contrast of dark wood and light wood veneer, as shown in Fig 12. To enhance the sense of space, the longitudinal grain of the floor accentuates the perceived length of the cabin, as does the longitudinal strip behind the stairwell as shown in Figure 13. The vertical grain direction on the rear wall is used to accentuate the height of the deck, also shown in Figure 13. The use of a clear plastic splash back in the kitchen enhances the levels of natural light in the table seating areas, as shown in Figure 14.

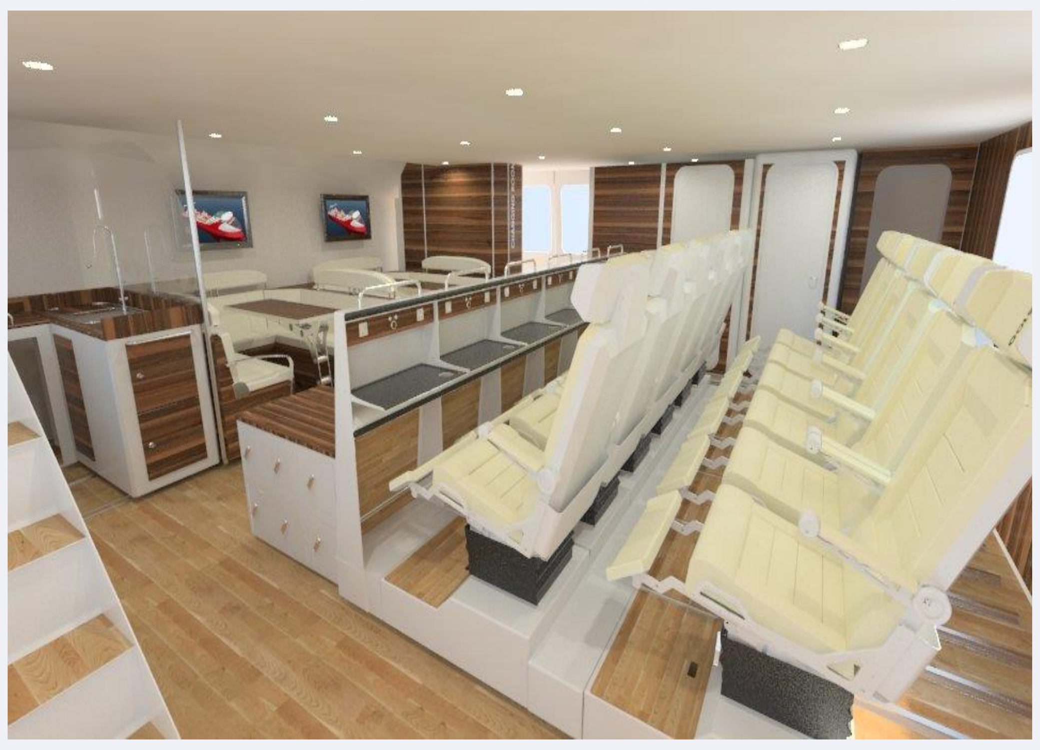
Figure 12: Rear 3/4 view of interior render

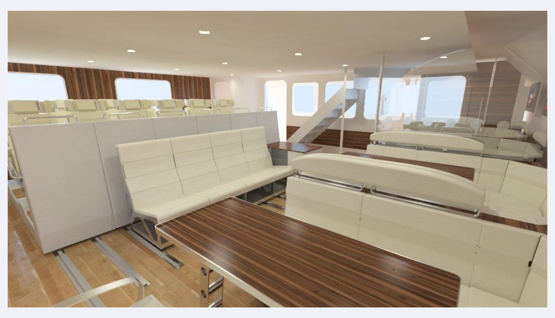
Figure 13: Rear 3/4 view of interior render


Figure 14 Rear 3/4 view of interior render from kitchen

The initial shower unit and toilet unit design did not communicate an initial sense of emotional engagement with the user as they would have to open the door to appreciate the level of refinement of the respective areas, shown as the white doors in Figure 12. In order to develop the emotional design aspect, a lighting innovation was implemented through the use of a translucent edge illuminated floor and back wall, to create a glowing display space that happens to be a shower and toilet, as shown in Figure 15. The use of thick plastic doors to simulate glass imposes the presents of the modules as a display area of warm light within the interior. In the same design meaning sense that Barilla designed a light that makes the user feel good. The use of the electrically activated polarised coating offers the user privacy when in use and visually communicates that a unit is in use. A second design proposal for the shower and toilet module is shown in Figure 16, here the design meaning is that of the en-suite of a luxury small apartment. The use of floating fittings and down lighting gives it a showroom like feel, with the use of a geometric toilet form to make it feel like a changing room rather than a toilet. Again the use of polarisable coating technology affords the user privacy and indicates that the unit is occupied.


Figure 15: Toilet and shower module (concept 1)


Figure 16: Toilet and shower module (concept 2)

Conclusions

This paper has demonstrated the potential of Marine Design as a multidisciplinary holistic design methodology, which offers competitive advantage through product differentiation and a significant reduction in both design and manufacturing costs. The use of 3D CAD systems enhances visual communication facilitating design dialogue with both client and other stakeholders, as well as fitters to optimise the construction process. The innovative use of surface scanning technology to ensure quality for installation through accuracy of fit, enables the design approach to be implemented in any yard.

Effective Design-Driven Innovation requires a range of technological interpreters and stakeholders both within an industry sector and in different industry sectors to facilitate Transfer of Innovation (TOI). KPM is uniquely positioned due to the diversity of activity in both automotive and marine sectors. The DDI design scenario developed has identified the need for vessel flexibility when trying to raise finance and spread risk in the business plan, given the uncertain market of the offshore wind farm industry and the potential opportunity of oil & gas. The technology innovation was implementation of the DFM process with digital technology, which can reduce production costs by as much as 30% as well facilitating vessel flexibility for both offshore wind and Oil & Gas sectors. By the adoption of these new production methods, design and cost control, the UK boat building industry will be able to compete in global market which will come under greater cost and price pressure.

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