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Innovative OSV Mothership for UK Round 3 Far Shore O&M

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European Boat Design Innovation Group – Wind Farm Support Vessels

Abstract

Research has indicated that current wind farm support vessels will not be appropriate for accessing the UK Round 3 far shore wind farms of the North Sea. In order to improve operability of WFSV accessing the far shore wind farms, mothership vessels will be required. Extrapolating the European Wind Energy Association's (EWEA) growth scenario for the period up till 2030 for employment in the installation, operation and maintenance, of offshore wind farms, it will be necessary to recruit land based technicians to meet the demand. Therefore, next generation motherships will need to address the user needs and aspirations of a new generation of technicians, who may not have previous marine experience. This paper presents a mothership concept design proposal, that challenges perceptions of the working and living environment on commercial vessels through the implementation of Design-Driven Innovation. The interaction between innovation of design meaning and technology innovation can transform the market within an industry and even create new market sectors. An analysis of the offshore wind market identified the challenges of vessel financing compared to the oil & gas sector, as a unique opportunity for a common platform technology vessel. The concept presented has an innovative WFSV launch/recovery system enabling a conventional OSV platform to be adapted into a mothership role. Resulting in a more cost effective solution in terms of design and construction that the benchmarked specialist vessels.

Environmental Psychology

Environmental psychology is an interdisciplinary field of research that addressed the relationship between humans and their surroundings. The term environment includes: natural environments; social settings; built environments learning environments; informational environments. The discipline is both value oriented and problem oriented, with the objective of solving complex environmental problems to achieve individual wellbeing within a larger society. [1] A critical tool to this approach is a model of human nature that predicts the environmental conditions under which humans will behave. This can help design, manage, protect and/or restore environments that enhance reasonable behaviour, predict the likely outcomes when these conditions are not met, and diagnose problem situations. The field explores a diverse range of issues including the following: the effect of environmental stress on human performance; the characteristics of restorative environments; human information processing; promotion of durable conservation behaviour. Environmental psychology relies on interaction with other disciplines in the design field such as: architecture; interior design; urban planning; industrial design; landscape architecture. [2]

Heerwagen [3] refers to the biological foundations of well-being, which distinguishes between “survival needs” and “well-being” needs. Survival needs deal with aspects of the environment that directly affect human health, such as clear air and water, lack of pathogens or toxins, and opportunity for rest and sleep. Well-being needs affect overall health through their relationship to fulfilment, quality of life, and psychological health. Where failure to satisfy survival needs may lead to serious illness or death, failure to satisfy the well-being needs produces the “gray life” of psychosocial maladjustment and stress related illnesses. The following well-being needs were identified as being directly relevant to building design [3], namely:

- Opportunity to engage in spontaneous social encounters
- Freedom to move between one social phase and another (from solitary work to group interaction)
- Opportunity to engage in a full range of species typical behaviours (creativity, self expression, cooperation, exploration)
- Opportunity for regular exercise
- Noise levels not much above or below that in nature
- Meaningful change and sensory variability
- An interesting visual environment

The biological approach forms the basis for a number of other theoretical perspectives relevant to design and well being. The common basis of which is the concept of “biophilia”, the evolutionary tie between people and nature. Taken as a whole, this diverse body of research suggests that building environments that contain the essential features of preferred natural settings will be more supportive of human well-being and performance than environments lacking these features. Considering a commercial vessel as a floating working environment, where well-being of crew is even more significant give the nature and potential costs of operational risks, this offers a potential Transfer of Innovation to support the design process. There is cross-cultural evidence that that savannah like environments are preferred over other habitat types. Furthermore, natural environments are consistently preferred over built settings, and built environments with trees, vegetation, and water are more liked than those lacking natural elements. Many large building complexes and cruise ships, create indoor garden features with large trees and plants, water features, daylight, multiple view corridors and comfortable retreats. The implementation of these design features substantiates a significant return on investment for the project developers.

Heerwagen [3] conceptualize the relationship between buildings and performance using a key framework from organizational psychology:

Performance = Ability x Motivation x Opportunity

Where performance is a function of the following factors acting together: ability; motivation; opportunity. A building can positively affect “*ability*” by providing comfortable ambient conditions, by enabling individual control and adjustment of conditions, and by reducing health and safety risks. A building can positively affect “*motivation*” by providing conditions that promote positive affective functioning, psychological engagement, and personal control. A building can affect “*opportunity*” by providing equitable access to conditions that reduce health and safety risks, equitable access to amenities, and compensatory design options where inequities exist and are difficult to eliminate entirely.

In defining the essence of a good building habitat, Heerwagen [4] refers to research in the behavioural sciences, which suggests a good building habitat supports the following needs and experiences:

- Connection to nature
- Sense of community and belonging
- Behavioural choice and control
- Opportunity for regular exercise
- Meaningful change and sensory variability
- Privacy when desired

She delineated the features and attributes of buildings that support these needs and experiences. Reporting that many studies show reduced adaptive load (less effort needed to adjust to an environment), reduced stress, improved emotional functioning, increased social support, reduced fatigue, and improved ability to focus attention on important activities. Steelcase research [5] on how the workplace can improve collaboration has identified that converging spatial, social and informational trends are creating demand for workplaces that support new patterns of collaboration. Knowledge work is accomplished in four different modes, which are essential to the process of building knowledge that in turn drives creativity and innovation: Focusing ; Collaborating; Learning ; Socializing. Across the four work modes, workers create and use two types of knowledge: explicit and tacit. Explicit knowledge is the formal, systematic information typically found in documents, procedures, and manuals. In contrast, tacit knowledge is deeply personal, harder to formalize, and learned by experience. It’s communicated indirectly through metaphor, analogy, mentoring, and side-by-side doing. Given the significant knowledge work nature of the technician role in the O&M activities of the offshore wind sector, Environmental Psychology offers a significant opportunity for Transfer of Innovation from the built environment to the commercial marine sector. .

Exterior Design and Technology Innovation

The stylised exterior form has a structural glass roof feature, which acts as a collector panel for a light tunnel system, which distributes natural light within the areas of the ship devoid of natural views. Inspired by sculptural and superyacht forms the exterior form was developed around the visual metaphor of a hand clasping a pebble. The hull is perceived as a visual form of strength that wraps itself around the pebble form of the accommodation module. The flowing sculptural form of the exterior, shown in Figure 1, seamlessly integrates the bridge level with the rest of the hull. The exterior design process began in side profile, were the dynamic stance of the visual form was developed, the visual mass of the exterior was moved forward to help create the dynamic stance make the vessel look as if it was moving when stationary. Refined through the use of line analysis to resolve relationships between lines and surfaces. The use of continuous horizontal windows in the fore section of the pebble connect it to the rear section which has a very different open deck form. The use of the flat architectural glass structure below the bridge gives it an imposing sense of scale from large architectural forms. The beam of the vessel has been increased to accommodate the BMT XSS WFSVs and a crane launch system. In the final version the bulwark is horizontal towards the transom as the visual mass of the WFSVs balances the bow pebble form.

Figure 1: Render of final exterior form proposal

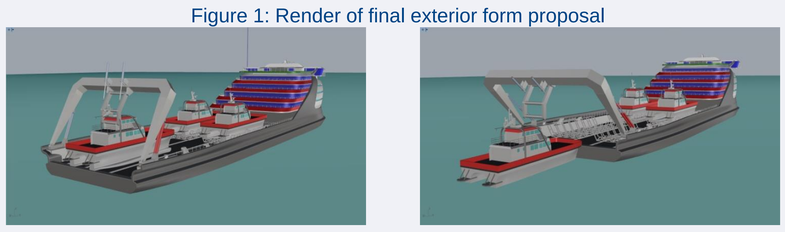

Figure 2: Operation of WFSV launch/recovery system

The technology innovation in this design proposal is the use of common platform technology. The idea is that a vessel could be design as a generic OSV vessel with a modular platform capable of being fitted with a transom mounted crane for the launch/recovery of WFSVs. There are two distinct launch/recovery systems under development. The first involves fitting a lifting frame onto both hulls of the WFSV as shown in Figure 2. Here the principle of operation involves driving the WFSV onto a bollard at the transom of the mothership under throttle, to partially constrain the axis of motion of the WFSV, enabling it to operate under Hs 2.5m conditions. A robotic arm system then secures a lifting hook onto the eyelet of the lifting frame. This has a flexible cable based mechanism to allow for the motion of the vessel in the 2.5m Hs sea state. The cable system raises the WFSV above the water and the crane retracts over the deck. At which point the cable lowers the WFSV onto a trolley and track based system, which allows the vessel to be moved forwards on an electrically powered bogies to make room for the second WFSV to be stored when recovered from the water.

The second proposal in development uses the same starting point of driving the WFSV onto a bollard, in this case the use of a lifting cage which is submerged just below the rear of the transom is raised to the underside of the WFSV in its partially constrained condition. It is then lifted clear of the water on a cable system and the crane retracted to transfer it to the deck of the mothership. The challenge in this proposal is transfer of the vessel from the lifting cage to allow the second vessel to be recovered. This will involve a modified track and bogie system to allow the WFSV to be driven forward from the lifting cage and the second WFSV to rest on the lifting cage when recovered.

Interior Design

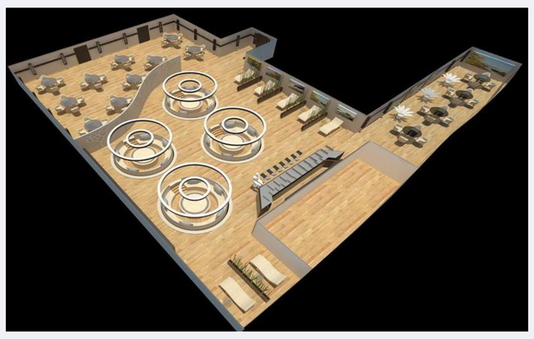

Figure 3: GA of restaurant with integrated lounge

The interior was informed by the principles of Environmental Psychology. The design objective was to create a number of interior design proposal for the key areas of the vessel. The key areas of the vessel were not only designed around aesthetics but also the atmosphere that the design would create. After a work shift the technicians would want to return to a very relaxed, tranquil environment. This was achieved through the use of very simplistic clean surfaces in the technician room concepts. The interior has been specifically designed to help encourage more female technicians into the industry. The first interior design area focused on was the restaurant with integrated lounge, on the basis that this was the most important area on the mothership as it was the first room the wind farm technicians experience before and after their work shift. The changing room is also an important area as it facilitates the technicians in making the transition from work environment to living environment.

A Scandinavian minimalist interior for the restaurant with integrated lounge, with the use of cream and light wooden floors is shown in Figure 3. There are four distinctive types of area, in the distance there is a serviced dining area for 40 people with integrated technology with the table for the user to interact with a menu and place an order. A partition segregates this from the communal informal lounge seating and individual loungers in the middle ground. The individual loungers have reed features to make them isolated from each other and the space. The communal informal lounge sofas have a recessed space and a table and overhead lighting identifying them as separate spaces and adding to the mood of the interior space. The coffee table area to the right has 16 seating places in tables of four for more intimate discussions without eating. There is a coffee and juice bar facing the round recessed lounge tables.

Figure 4: Seating area with biophilic lighting features and textures

The second concept has a strong biophilic and luxury influence inspired by an airport business class lounge. The seating area with biophilic lighting features are shown in Figure 4. The use of plants and natural stone effect combined with the use of edge lighting of the ceiling gives the natural stonewall texture a sense of atmosphere. The tree reference as a structural motif within the lighting features at the centre of the lounge seating and the organic form chairs is an engagement in biophilic design. The use of hard wood flooring compliments the natural stone effect.

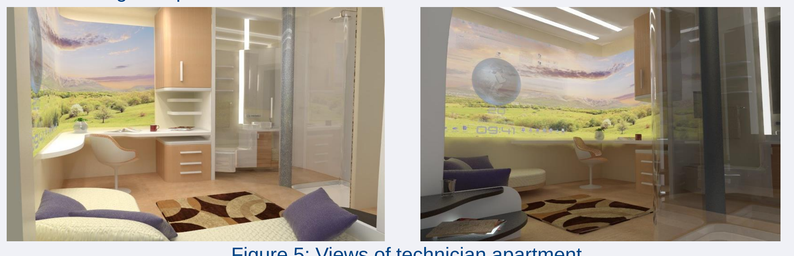

Figure 5: Views of technician apartment

Figure 6: Use of Murphy bed to adapt space

The technicians room concept, show in Figure 5, uses a smart wall to simulate views of nature as well as interactive media content. The minimalist design and the use of light wood and lighting make it appear spacious. The use of a Murphy bed in the design enhances the design meaning making it feel like a small apartment luxury lounge, shown in Figure 6, by enhancing the sense of space when the bed is stored.

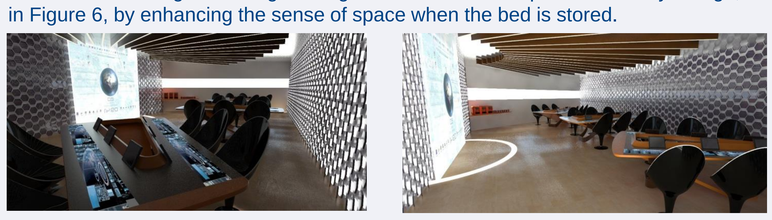

Figure 7: Views of meeting room

The meeting room concept is shown in Figure 7, where the acoustic absorbers on the ceiling have the smart wall as a focal point. The shape of the tables facilitates the viewing angles from all the chairs to ensure a clear view of the smart wall for all users. The use of an industrial style surface pattern provides sensory variability for the user. The continuous horizontal window provides views of the seascape. The integrated tablet workstation technology at each seat combined with individual viewing screens provides the capability to work in small groups and individually, with the transition between the two modes of working facilitated by customised social media tools. The use of the smart wall facilitates virtual collaboration with a range of group sizes.

Figure 8: GA of changing room

Figure 9: View of changing room entrance

Figure 10: View from the changing area

The GA of the changing room is shown in Figure 8 with the view of the entrance from the shower unit is shown in Figure 9. The view of the entrance from the changing area and the view of the lockers from the toilet area shown in Figure 10. The use of lighting and the contrast of highly reflective surfaces and granite gives it a clinical feel and modern style appeal. This modern style approach creates the impression that a room is larger than it actually is. The minimal use of textures and bold geometric forms in the furniture, combined with the use of neutral colours accented with a single bold colour along with polished finishes and asymmetrical balance of layout are key identifying features of this style. Use of radius edges at floor and ceiling accentuate the perception of height.

Conclusions

Future changes in the PAX regulations of CTVs and crew transfer to turbine technology could radically modify O&M strategy business models. This requires the mothership to be a highly adaptable platform that can be readily and cost effectively reconfigured for a range of CTV types and deployment solutions. The two CTV launch/recovery solutions proposed will be evaluated in the further work of the authors in this context to quantify potential benefit and ROI. The recent exterior design developments by leading companies in the commercial vessel sector indicates that they are developing an appreciation of the marketing value of exterior form as part of the brand value and perception.

Given the significant knowledge work nature of the technicians role in the O&M activities in the offshore wind sector, Environmental Psychology offers a significant opportunity for Transfer of Innovation from the built environment to the commercial marine sector.

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